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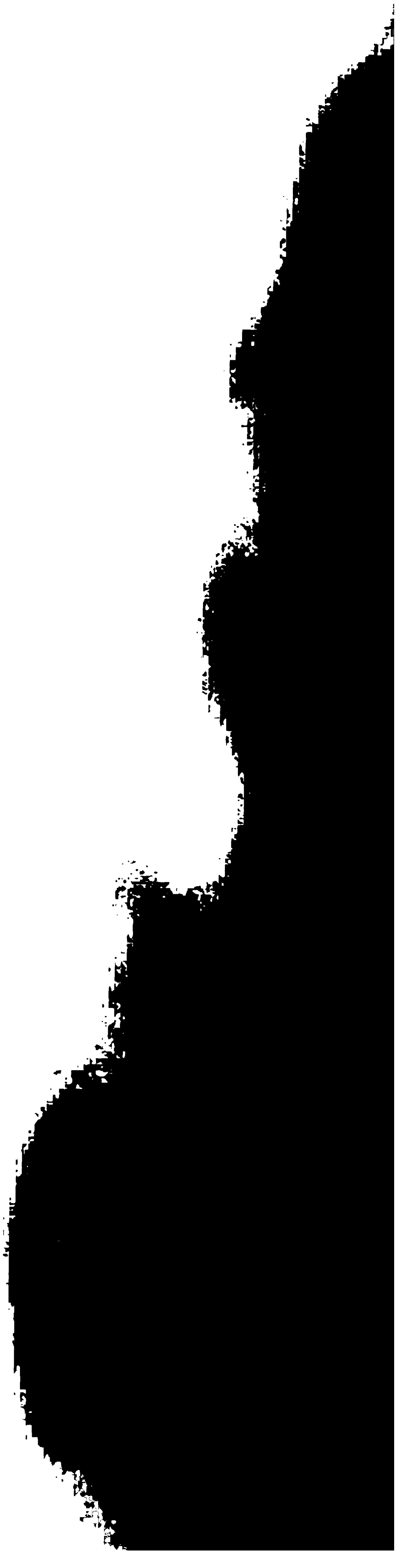

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

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FOREST CONDITIONS

IN THE

ABSAROKA DIVISION OF THE YELLOWSTONE FOREST RESERVE, MONTANA

AND THE

LIVINGSTON AND BIG TIMBER QUADRANGLES

BY

JOHN B. LEIBERG

WASHINGTON
GOVERNMENT PRINTING OFFICE
1904

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 10, 1904.

SIR: I have the honor to transmit for publication, as a professional paper, a report by Mr. J. B. Leiberg on the forest conditions and land classification of the Absaroka division of the Yellowstone Forest Reserve and adjacent regions.

Very respectfully,

HENRY GANNETT,
Geographer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

FOREST CONDITIONS IN THE ABSAROKA DIVISION OF THE YELLOWSTONE FOREST RESERVE AND THE LIVINGSTON AND BIG TIMBER QUADRANGLES.

By JOHN B. LEIBERG.

ABSAROKA DIVISION OF YELLOWSTONE RESERVE.

LOCATION AND EXTENT.

The tract of land here designated the Absaroka division of the Yellowstone Forest Reserve was originally the Absaroka Forest Reserve. By proclamation of January 29, 1903, this reserve was merged with the Teton and the Yellowstone forest reserves, the whole taking the name of the Yellowstone Forest Reserve. The western, northern, and eastern boundaries, as then established and as applicable to the Absaroka division, are as follows:

"Beginning at the point where the range line between ranges nine (9) and ten (10) east, principal meridian, Montana, intersects the northern boundary of the Yellowstone National Park; thence northerly along said surveyed and unsurveyed range line, allowing for the proper offset on the first (1st) standard parallel south, to the southwest corner of section eighteen (18), township four (4) south, range ten (10) east; thence easterly to the southeast corner of said section; thence northerly to the northeast corner of section six (6), said township; thence easterly to the southeast corner of section thirty-two (32), township three (3) south, range ten (10) east; thence northerly to the northeast corner of section five (5), said township; thence easterly along the township line to the northeast corner of township three (3) south, range eleven (11) east; thence southerly to the southeast corner of said township; thence easterly along the surveyed and unsurveyed township line to the point for the southwest corner of township three (3) south, range fourteen (14) east; thence northerly along the surveyed and unsurveyed range line to the northwest corner of township two (2) south, range fourteen (14) east; thence easterly to the northeast corner of said township; thence southerly to the point for the southeast corner of said township; thence easterly to the point for the northeast corner of township three (3) south, range fifteen (15) east; thence southerly to the point for the southeast corner of said township; thence easterly along the surveyed and unsurveyed township line to the northwest corner of township four (4) south, range eighteen (18) east; thence southerly along the range line to its intersection with the first (1st) standard parallel south;

thence easterly along said parallel to the northeast corner of township six (6) south, range eighteen (18) east; thence southerly along the surveyed and unsurveyed range line to the southwest corner of township seven (7) south, range nineteen (19) east; thence easterly to the northwest corner of township eight (8) south, range twenty (20) east; thence southerly to the southwest corner of said township; thence easterly to the southeast corner of said township; thence southerly along the range line to its intersection with the boundary line between the States of Montana and Wyoming."

The southern boundary of the area discussed is west from the point where the eastern boundary of the reserve intersects the Montana-Wyoming line to the southeast corner of township 9 north, range 14 east; thence along the northern boundary line of the Yellowstone National Park to the point where said boundary line of the park intersects the range line between ranges 9 and 10 east, principal meridian. The total area, as above delineated, includes 1,334,400 acres.

CLASSIFICATION OF LANDS.

The lands in the division are classified as follows:

Classification of lands in the Absaroka division of the Yellowstone Forest Reserve.

	Acres.
Forested	442,640
Wooded	37,200
Nontimbered	854,560
Total	1,334,400

The nontimbered lands vary in character and are classified as follows:

Classification of nontimbered lands in the Absaroka division of the Yellowstone Forest Reserve.

	Acres.
Badly burned	138,410
Agricultural	34,840
Grazing	388,170
Bare rocks, high alps, and snow fields	260,640
Lakes and tarns	32,500
Total	854,560

TOPOGRAPHY.

OROGRAPHIC FEATURES.

The area discussed consists of a vast body of Archean gneisses and similar rocks carrying on its flanks upturned strata of Paleozoic and Mesozoic ages. In some localities outflows of lava rest upon the older rocks. In the northeast corner it also includes a low, terraced, undisturbed limestone area, which now constitutes a rolling foothill region. During Pleistocene times the uplift was covered with a great glacier, which, moving in various directions, but chiefly west and north, sculptured and fashioned the region much as we now find it.

The most extensive degradation of the uplift, with consequent roughness and irregularities of the contours, is found on the area situated west of Stillwater River. This portion of the reserve is scored by deep gorges with intervening narrow ridges, the crests often only a few feet wide. There are many canyons, narrow and rocky, strewn with masses of bowlders and gravel left behind by the glaciers which plowed their way to the lowlands through these valleys. In some places the glaciers left large blocks of country with broad, rolling, bowlder-strewn, plateau-like surfaces standing up massively and majestically between the larger canyons. Of this character are the so-called East and West Boulder plateaus, which represent areas of the uplift not greatly reduced from the height to which they had been elevated when the ice age began. The altitude of the region varies from 4,000 feet in the lowest canyon bottoms to 11,000 feet on the summit of the highest peaks, the average elevation being probably not far from 8,000 feet.

East of the canyon of Stillwater River the region has a considerably higher mean elevation, probably not less than 9,800 feet, excluding the foothill region. The glacier, in its northward movement to lower levels, cut its way down through the uplift for thousands of feet, leaving a series of stupendous cliff-bound gorges, producing some of the wildest and grandest scenery imaginable. At the head of these gorges are numerous peaks and pinnacles, some of them rising to altitudes of 13,000 feet, while beyond the line of canyon erosion a high, plateau-like area remains, pitted with numerous depressions, intersected by ridges and cones, furrowed by shallow ravines, and studded with low buttes and occasionally dome-like elevations. This elevated tract is named Beartooth Plateau, and is a prominent feature in the orography of the southeast quarter of the reserve.

The plateau varies from 10,000 to 12,000 feet in altitude; much of it is rolling, and in a few localities is almost a level tract with a moor-like aspect, but the greater portion presents a decidedly rugged surface. Most of the depressions hold lakelets or tarns. The plateau has a gradual slope southward to Clark Fork Valley. On the west it is bounded by the canyon of the Stillwater, while along the east line of the reserve the tract breaks off to the level of the plain with steep, almost perpendicular, fronts, in some places over 3,000 feet in height.

The general character of the canyons has been mentioned above. The canyons of the two Rosebuds in their upper areas are mere narrow rifts between nearly perpendicular rock walls, 1,500 to 2,000 feet in height, while along Stillwater Canyon the cliffs in some places tower over 3,000 feet above the floor of the canyon. Here and there the canyon floors are littered with glacial débris, which occasionally has dammed the streams and formed lakes.

The highest point in the reserve is Granite Peak, which reaches nearly 13,000 feet (12,900 feet, as obtained by aneroid). There are scores of other elevations throughout the reserve varying from 10,000 to 12,000 feet. Notwithstanding these

considerable altitudes, far above timber line, there is not a single snow peak in the reserve. Permanent snowfields occur in many localities in the high areas, but they are simply the result of heavy winds piling up great banks of snow in gullies, ravines, and on the lee side of the higher peaks, too deep to melt during the short summer season, but yearly waxing and waning according to the severity of the winter's downfall of snow.

DRAINAGE.

Primarily the area discussed is situated wholly within the Yellowstone River drainage. The run-off from its areas is carried into this river by a large number of creeks and streams, which head mostly in the alpine and subalpine tracts. Some of the streams form the heads of rivers of considerable size, others are mere alpine rivulets. The larger and more important of the drainage basins and streams are as follows: (1) The Boulder River drainage, composed of (*a*) the heads and central areas of West Boulder River; (*b*) the head and central areas of Boulder River; (*c*) the head, middle, and most of the lower portions of East Boulder River. (2) The upper half, including all the heads, of Stillwater River. (3) The Rosebud drainage, composed of (*a*) the head and central areas of West Rosebud Creek; (*b*) the head and central areas of East Rosebud Creek. (4) The head of Red Lodge Creek Basin. (5) The Rocky Fork drainage, composed of (*a*) all of West Rocky Fork, and (*b*) the head and upper central areas of East Rocky Fork. (6) The northern heads of Clark Fork drainage. (7) The head and central areas of Slough Creek drainage. (8) The head and central areas of Hell Roaring Creek Basin. (9) The head and central areas of Mill Creek.

With the exception of Clark Fork, more than 99 per cent of the water which these streams carry represents run-off originating within the reserve. The tract is thus a huge reservoir, furnishing a very large part of the annual flow in Yellowstone River, and is therefore of very great importance to the irrigation interests dependent on the waters of that stream. Excepting Slough and Hell Roaring creeks, all the streams noted above are more or less utilized for irrigation purposes above their confluences with Yellowstone River.

The volume of water discharged by these streams during the summer season [illegible] be greatly augmented by the construction of reservoirs in the alpine and subalpine areas at their heads.

ROCK FORMATIONS AND SOIL.

Three-fourths of the area discussed consists of a great Archean uplift, cut and seamed by dikes of various kinds of igneous rocks. The remainder consists of lavas of various composition, limestones, and sandstones of Paleozoic age. The limestones occur chiefly in the northern areas, flanking the first rises of the mountains along

the foothill region. They stretch northward and form most of the foothills, but are there commonly deeply buried under gravel and bowlder drift. They also occur along Boulder River, as far up as the central areas, and at the head of Stillwater River in the Cooke City region. There are also outcropping strata of limestones in the southwestern portion of the reserve, in Slough Creek Valley, on Buffalo Plateau, and farther westward. The lavas occur throughout all the areas west and northwest from Cooke City. For the most part they have been ejected from vents or craters in the region around Haystack Peak at the head of Boulder River. In part they are brecciated lavas and probably ejected through fissures. There is also a large field of these lavas in the northern part of the reserve, beginning on the left bank of Stillwater River, in the southeast corner of T. 4 N., R. 15 E., whence it stretches northward and eastward 10 to 25 miles.

The soil in the area is of two principal varieties, a siliceous loam derived from the disintegration of the prevailing granitic rocks with admixtures of mold and vegetable débris, and gumbo soils derived from the decomposition of the modern lavas. The former soils are more common and occur throughout the reserve; the latter are confined to the areas where they are underlain by rocks from which they were derived.

The siliceous soils are generally poor, except in swales and depressions, where large accumulations of vegetable mold have been washed in from the surrounding high ground. In most places the surface of the soil is strewn with bowlders. The substratum or basement is always composed of sand and gravel with bowlders freely interspersed, the whole easily displaced and gullied when the turf or forest on its surface is from any cause destroyed or removed.

The gumbo soils are hard and tough when dry, but when wet dissolve almost like soap and are easily gullied and washed. Wherever these soils occur in the non-timbered or woodland areas of the foothills and have been denuded by excessive pasturing, gullying is taking place. They possess a much greater degree of fertility than the siliceous soils, and in the forested areas bear the heaviest stands of timber in the reserve.

MINING AREAS AND MINERALS.

The area discussed contains several mineralized areas and mining camps, in some of which more or less activity is displayed in the extraction of ore, while in others no mining operations are now being carried on. The principal mining districts are as follows: Boulder River, to its head in the region around Haystack Peak; the divides at the head of Stillwater River; the southern and main tributaries of Clark Fork and Soda Butte Creek, a district with Cooke City as its center; Horseshoe Mountain, a small tract between upper Slough Creek and Stillwater River; the central areas of the Stillwater Valley around Nye and the region along and at the head of Crevice Creek. Lesser and little known or prospected mineralized areas occur in the canyons of East and West Boulder rivers. The great mass of the reserve, all the granite areas of the Absaroka Range west of Boulder River and the vast granite uplift east of Stillwater River are, so far as known, devoid of mineralized areas.

The mineral areas embrace both quartz and placer mining. Most of the placer districts are confined to the Boulder drainage. Cooke City and Horseshoe Mountain districts are chiefly mining in quartz. The Horseshoe Mountain camp and Cowles, at the head of the Boulder, were the only camps in which active mining operations were in progress at the time this examination was made. In the foothills in T. 6 S., R. 18 E., indications of petroleum are believed to have been found, and prospecting has been in progress for some years without any very definite results.

AGRICULTURAL LANDS.

The areas actually under cultivation or susceptible of tillage without special irrigation works comprise 34,840 acres. Of this amount, 4,000 acres exist in small scattered tracts, forming bench lands, swales, reclaimed or drained wet meadows, in the various canyon bottoms, chiefly in those of Boulder and West and East Boulder rivers, in Stillwater Valley, and in the lower portions of Rocky Fork Canyon. The remainder of the agricultural areas lie in the foothill region, especially in Tps. 4 and 5 S., Rs. 16 and 17 E., and in T. 6 S., R. 18 E. The amount actually under cultivation on areas situated within the mountain region amounts to 1,200 acres, approximately, while in the foothill areas, chiefly in the townships enumerated, there are possibly a total of 8,000 or 9,000 acres under more or less complete tillage. The altitudinal limit of the arable lands lies between 5,000 and 6,000 feet. The large tracts of subalpine meadow lands lie at altitudes too high for the successful raising of crops of any sort. The agricultural lands in the foothills actually under tillage usually occupy swales and bottoms along the different creeks. They have a deep and rich soil, while the lands under tillage in the various canyons consist of shallow strata of loam spread over a clear gravel, pebble, or bowlder basement, and, therefore, have only a small and passing value for farming purposes. Most of the lands require irrigation for the production of crops.

GRAZING LANDS.

The nontimbered lands in the reserve available for range or pasture purposes comprise 388,170 acres. To these should be added grassed woodlands of 37,200 acres, making a total of 425,370 acres of grazing lands. These tracts are of different values for range purposes, depending on their general character and their situation as regards accessibility and water supply. They may conveniently be divided into five classes, as follows: (1) Nontimbered foothills; (2) woodlands; (3) open slopes, generally southern, and nontimbered canyon bottoms; (4) wet meadows and fire glades in the subalpine forest zone; (5) summits of the high plateau areas and ridges above timber line.

The nontimbered foothills comprise 100,000 acres. They lie along the northern and northeastern edges of the area, in the northwest corner, forming a narrow and interrupted belt, gradually widening toward the east until they occupy most of Tps. 4 and 5 S., Rs. 16 and 17 E. and T. 6 S., R. 18 E. The tracts have a mean altitude of 5,600 feet. The surface is marked, in part, by long, rolling swells and low ridges alternating with shallow canyons, and, in part, is extensively cut up and intersected by a multitude of ravines. The soil is generally thin and stony, most of the areas being overlain with deep deposits of glacial bowlder and gravel drift, but, where the soil has been derived from disintegration of the brecciated lavas, it is of a gumbo-like character. The lands are generally well watered by small springs, runs, and streams, although many of the smaller ravines are dry through the latter part of summer and fall.

Originally these tracts bore a moderately close sward of various species of grasses. They have long been pastured, and, where uninclosed and only moderately well watered, have now a very low grazing value.

The lands are of little value for forestry purposes, although they are by no means incapable of supporting arborescent vegetation. They are situated within the altitudinal limits of timber growth, and were they not pastured would, in course of time, produce stands of aspen, cottonwood, limber and yellow pines. Their present treeless character is primarily due to repeated fires during the Indian occupancy of the region.

The woodlands comprise 37,200 acres. They occupy narrow and irregular tracts throughout the foothill areas, generally at altitudes not much above nor below 6,000 or 6,200 feet, following streams and gullies, or occupying crests and northern slopes or combs of ridges, or scattered over the rolling surface of the higher foothills. Portions of the areas are rocky in character, with projecting ledges of limestone and brecciated lava. Portions of the tracts consist of deep deposits of glacial bowlder and gravel drift. Most of the tracts are poorly watered, springs being scarce and the different runs and ravines mostly dry during the summer season. They are sparsely stocked with limber pine, yellow pine, red fir, aspen, and cottonwood, set in small copses, thin lines, or standing as isolated trees. Their grazing value lies in the abundant growth which forms most of the ground cover where not overpastured. Where the tracts have been too closely grazed they are bare or overgrown with coarse weeds. In some localities the creeping juniper, *Juniperus procumbens*, spreads over the ground in close and dense mats. In general the woodlands have not been badly pastured, chiefly owing to lack of water, and, being situated at easily accessible points, they are still of considerable grazing value.

Most of the area of this class of lands is capable of bearing forests, probably not in uniform and heavily stocked stands, but in moderate volumes, 1,200 to 1,800 cubic feet per acre for mature growths. Their present thin and scattered stockage is entirely due to often repeated fires during the Indian occupancy of the country. In places where grazing for various reasons has been kept at a minimum, and where no fires have run during the past two or three decades, heavily stocked stands of sapling red fir are pushing out into the previously nontimbered or sparsely timbered areas, conclusively proving that under proper conditions the tracts will bear forests.

The pasturing of the woodlands is inimical to rapid extension or closer stockage of the timber growth. Any sheeping of the areas will practically destroy whatever seedling growth may be springing up on such grazed-over tracts. The pasturing of horses and cattle, while destructive in a less degree, is yet likely, if carried to excess, to have the same effect on the seedling growth as the sheeping.

The woodlands do not give rise to any notable quantities of run-off. They are of no particular importance in this region as adding to or conserving the water flow, and extensions or additions to their present stockage would be chiefly beneficial in giving easily accessible wood supplies to agricultural settlements in the adjacent timberless valleys.

The third class of grazing lands, consisting of open slopes and nontimbered canyon bottoms, comprises 25,000 acres. These exist throughout all parts of the reserve at altitudes ranging from 6,000 to 8,000 feet. In part they comprise slopes generally with a southern exposure, but not infrequently an eastern or western, rarely a northern. In part they are made up of meadows and swales fringing the creeks and canyon bottoms. The slopes chiefly represent ancient fire glades which, before the advent of the white man, were covered with forest. They were burned over by the aborigines, and owing to ensuing soil aridity have never restocked. In most localities the soil cover on these tracts is thin, the underlying rough talus stratum or solid rock comes near the surface, there is a rapid-drainage ratio, and little reserve moisture is stored in the shallow subsoil. Hence when denuded of forest cover restockage is an extremely slow process and the land remains grass-covered for an indefinite time. They commonly bear an abundance of grass, but owing to steepness of slope are rarely pastured to any extent. If left undisturbed, the forest will eventually cover them again. Of the total area in this class of grazing lands 15,000 acres consist of open slopes, as described.

The remainder of the lands in this class, 10,000 acres, is made up of many small glades and meadows. Their timberless character is due to the prevailing swampy nature of the ground—the soil-moisture ratio being too high for coniferous growth.

In part the glades bear close swards of paludose grasses and sedges; in part they are covered with a more or less open tangle of willow brush. The clean grassy or sedgy portions are occasionally used as natural hay meadows. The willow-covered tracts are pastured by cattle and horses.

At higher altitudes, 7,500 to 9,500 feet, is found the fourth class of grazing lands. They consist of wet meadows of very ancient fire glades in the subalpine forest and of ground thinly stocked with open stands of that type of forest. In the aggregate, 70,000 acres belong to this type of grazing lands.

The meadow portion consists of swampy, marshy tracts at the heads of streams and of narrow, springy margins fringing lakelets and tarns. They occur throughout the reserve along all the main divides, but are more abundant and contain a larger acreage than elsewhere in the following localities: Summit of Buffalo Plateau in T. 9 S., R. 11 E.; at the head of Stillwater River in T. 9 S., Rs. 14 and 15 E.; and at the head of Clark Fork in T. 9 S., R. 15 E. These tracts, as well as the rest of the class of lands to which they belong, are of great importance in conserving and regulating the water conditions of the region. They are, in effect, vast sponges, absorbing and holding back surplus flood waters early in the season, and gradually releasing the stored-up volumes as summer advances.

The swampy areas are devoid of arborescent growth except for scattered willows here and there. The dry tracts are either bare or thinly stocked with trees. When timberless it is owing to past fires and deficient restockage, largely caused by the prevailing low seed-producing capacity of the high subalpine forest. Few of the tracts are pastured at the present time. Many of them are inaccessible except to sheep, which were formerly ranged in a few localities; but the marks of such sheeping are now nearly obliterated. During the Indian occupancy the areas accessible from the National Park were used by the buffalo as summer ranges. They are dotted with the wallows and marked by the deep, well-worn trails of these animals. The tough, close sward of grass and sedge which covers these tracts will bear a considerable amount of hard usage before becoming overgrazed; but owing to the important part they occupy in the conservation and regulation of the outflow from the region only a very limited amount of stock should be permitted, while the regulations excluding sheep should be continued in full force, as at present.

The largest area of available pasture lands in the reserve is included in the 5th class and comprises the summits of the different plateaus and the true alpine regions generally. In the aggregate, the class covers 156,000 acres. Most of the lands are situated in that part of the reserve which lies east of Boulder River, and particularly in Tps. 6 and 7 S., Rs. 13 and 14 E., Tps. 8 and 9 S., Rs. 18, 19, and 20 E., embracing tracts belonging to Lake and Beartooth plateaus. Other large tracts of this class of lands occur in Tps. 4 and 5 S., Rs. 11 and 13 E., on the summits of West and East Boulder plateaus. Smaller tracts are scattered along the crests of the higher divides.

As a rule, lands of this class are difficult of access from the plains, from the foothill regions, and from the bottom of the canyons which bound or cut into them. They lie at altitudes varying from 9,500 to 12,000 feet, and the grazing season on them is short. The various plateau areas which so largely compose them are broad summits of the great Archean uplift of the region, smoothed in some localities, eroded and roughened in others. They are bordered by enormous, cliff-bound canyons on most of their sides, and when they front directly on the plains, as in the southeast corner of Beartooth Plateau, present extremely steep slopes. In some places the surface is rolling, as on the summits of East Boulder and the northern areas of the Beartooth Plateau; at other places it is pitted with bowl-like or elongated depressions commonly partly filled with water; at other points there are combs, ridges, and dome-like elevations of solid rock or heaped-up masses of bowlder drift, resembling the "nunataks" described as projecting above the surface of the arctic continental glaciers. Streams head in the various tarns or in the springs with which the tracts are liberally supplied, and become important feeders of the rivers and creeks in the reserve.

Where not too closely sheeped in the past and where sufficient soil overlies the rock or bowlder basement the land is covered with a close and very tough sward of alpine and subalpine grasses and sedges, and in the height of the summer is brilliantly bespecked with multitudes of many-hued flowers. Around the springs and points of seepage and in crevices of rocks grow tangled thickets of frutescent willows, while on the more level and drier ground the herbaceous arctic willow, rising scarcely 2 or, at the most, 3 inches above the surface of the soil, spreads its thin mats and twigs along the grassy sward.

All the larger and more easily accessible of these tracts have been pastured, none very closely except the Beartooth Plateau areas in Tps. 8 and 9 S., Rs. 18, 19, and 20 E., which have for many years been favorite sheeping grounds for flocks owned in the vicinity of Red Lodge and in adjacent townships across the Wyoming line. Everywhere throughout these sheep runs the land has been overgrazed, and coarse alpine plants, worthless for pasturage, have either wholly or in part supplanted the former grassy turf, or where other species of vegetation have not usurped the ground the grass remaining has been eaten so close that only mere stubs remain.

Situated above timber line lands of this class are, of course, of no particular importance in the forest economics of the reserve. They have, however, a large and far-reaching value as conservators and retainers of the precipitation on the region and as regulators of the run-off. Their lakelets and tarns are effective natural reservoirs, and are so situated that by means of low embankments across their outlets their storage capacity can readily be increased tenfold or more. Where lakelets and tarns are lacking, or where they have been drained by the erosion of the natural dams at their outlets, marshes and springy ground have taken their place and serve the same function in the regimen of the streams at their sources. The grassy turf on the uplands and around the margins of the lakelets and tarns, and the tangle of willows and heavy sward which spreads over the swampy and marshy tracts have the same beneficent influence and action on the water conservation in these alpine areas that the forest cover has on the regions at middle elevations. The grass cover effectually prevents gullying and excessive evaporation. If the grass is destroyed gullying begins, the loosened material silts the hollows and depressions that hold the lakelets, the water level is raised without corresponding elevation of the natural embankments at their outlets, and finally the lakelets are levelled and drained. In order that the grass cover of these tracts may remain intact and serve the important purpose it now does, grazing will have to be closely watched and regulated. Sheeping, whether in large or small bands, should be entirely prohibited, and the number of cattle and horses allowed on the tracts should be restricted to the lowest possible number. On the lands included in Beartooth Plateau and situated within the area discussed, gullying is apparent as yet only in isolated localities and has not proceeded to any alarming extent. But on the lands of the plateau across the Wyoming line and in the region surrounding Beartooth Lake, the evil effects of overgrazing, as displayed in the formation of gullies, are abundantly in evidence. Great gullies are opening out in the slopes of the ridges hemming in this lake on the west, the gullying following exactly the lines of excessive sheeping. On this particular tract a large band of cattle was pastured during the summer of 1903. They were rather closely herded, and to escape flies and other insect pests were accustomed to bunch up on comparatively small tracts near the lake. Where this bunching occurred, as well as on adjacent areas which were being overgrazed in consequence, the turf was quite as completely destroyed as ever it was on bedding places of sheep, showing that there are no essential differences in the effects following overgrazing, whether accomplished by cattle or sheep.

LAKES AND TARNS.

Bodies of standing water, other than marshes and swamps, cover 32,500 acres of the reserve. Without exception they owe their existence to past glacial action. Some occupy shallow basins and glacial cirques in the alpine areas, dammed and held back by ledges of rock, or by walls of morainic débris across their outlets. Others are situated in the bottoms of canyons and are formed and held back by the remains of terminal moraines stretching across the valley. Most of them are shallow and of small area. The largest in the reserve is Mystic Lake in T. 7 S., R. 16 E., covering 1,500 acres, situated in the canyon of West Rosebud Creek. The lakelets are most numerous in the southern portions of the reserve, in the high, extensively glaciated alpine areas east of upper Stillwater River, where they are found by the hundreds, occupying shallow depressions in the great granite uplift of the region. Rarely they lie singly; usually they are in groups of 4 to 7 or more, connected by little rivulets. Sometimes they are fringed by narrow belts of timber or lines of brush, but more frequently their surroundings are bare rocks, or steeply sloping tracts of alpine meadow down to the water's edge. They are gradually disappearing, in part by silting from adjacent slopes, and in part by deepening of their outlets and consequent drainage. A large number have disappeared in this way and now form tracts of merely marshy ground.

The lakes of the reserve are of great importance, in view of future plans for water storage. Scores of the small ones could be turned into large lakes by moderate and not costly embankments across their outlets. All the streams heading in them are feeders to rivers whose waters are utilized for irrigation in the agricultural districts in the lowlands, and there can scarcely be any doubt that in course of time these natural reservoirs will be enlarged and utilized to the utmost.

FOREST CONDITIONS.

COMPOSITION AND RANGE.

The forest in the reserve is almost wholly coniferous, and is made up of the following species:

Limber pine	Pinus flexilis
Lodgepole pine	Pinus murrayana
Yellow pine	Pinus ponderosa
White pine	Pinus monticola
White-bark pine	Pinus albicaulis
Red fir	Pseudostuga taxifolia
Subalpine fir	Abies lasiocarpa
Engelmann spruce	Picea engelmanni

The deciduous trees are represented by aspen, cottonwoods, various species of arborescent willows, hawthorn, wild cherry, and service berry. The species of trees with diameters exceeding 3 inches at the base occur in the following proportions:

Composition of forest in Absaroka division of Yellowstone Reserve, including trees of all species [illegible] diameters of 3 inches and upward.

	Per cent.
Limber pine	2.3
Lodgepole pine	45.6
Yellow pine	.005
White pine	[illegible]
White-bark pine	[illegible]
Red fir	12.2
Subalpine fir	11.1
Engelmann spruce	21.8
Aspen and cottonwood	1.6
Other species of broad-leafed trees, less than	.05

The general arrangement and distribution of these species is simple. At elevations of 5,500 to 6,000 feet limber pine, small proportions of yellow pine, and scattered copses of red fir form thin fringes of forest, or, on northern slopes, fairly well-stocked stands. From 6,000 to 8,000 feet lodgepole pine forms the great mass of the forest. It occurs either in practically pure growths, generally closely stocked, or mixed with red fir and Engelmann spruce; the red fir is particularly abundant on dry, rocky slopes; the Engelmann spruce is most common along the canyon bottoms, in places with considerable seepage or where the lodgepole pine has attained an age of 150 years and upwards. Above the 7,800-foot level the lodgepole pine thins out and is replaced by white-bark pine, subalpine fir, and Engelmann spruce, which together constitute the subalpine forest zone. The broad-leafed trees—aspen, cottonwood, and arborescent willows—are mostly confined to the canyon bottoms, and are seldom found above the 7,500-foot level.

The timber line is at an elevation of about from 9,300 feet on northern and western slopes to 9,800 feet on southern exposures. It rises, however, as the eastern edge of the reserve is approached, until in some places along the eastern verge of Beartooth Plateau it reaches 11,000 feet. Near the timber line Engelmann spruce is found in greater abundance and vigor than any other species. Next comes the white-bark pine, while the subalpine fir generally occurs at lower altitudes. Both the spruce and white-bark pine dwindle rapidly in stature as elevation is attained, until at their uppermost limits they are mere depressed shrubs.

Within their altitudinal limits the species, except the white pine, are found in the timbered area in all parts of the reserve. Their relative abundance, however, varies greatly. The limber and yellow pines are most common in the foothills in the northern townships; the yellow pine, however, forms in all cases a very small ratio of the timber in any locality and is practically lacking in all of the interior areas. The white pine occurs chiefly in the bottoms of Davis Creek, an affluent of West Boulder River, and in the Slough Creek bottoms in T. 10 S., R. 12 E. It is a very rare species in either locality, only scattered trees occurring, set in mixed stands of lodgepole pine, red fir, and Engelmann spruce. The white-bark pine is found throughout the subalpine zone. Usually it forms only a small proportion of the forest, but occasionally, as in the eastern portion of Hell Roaring Creek Basin, it becomes so abundant as to constitute 75 to 85 per cent of the stands.

The lodgepole pine is very plentiful; it forms fully 75 per cent of the forests below the subalpine zone, and, excluding the lower areas bearing red fir and limber pine, will amount to 90 per cent. It frequently forms nearly or quite pure growths, especially while in the sapling stage, and in mature stands where the forest is beginning to assume its normal composition seldom falls below 35 to 50 per cent. Its relative abundance and preponderance are wholly the result of past fires.

The red fir extends throughout the lower areas of the reserve. It occurs in small stands of pure growth while in the sapling stage, and in more or less mixed stands as mature age is reached. Lodgepole pine is its most common associate in the mixed stands, with lesser proportions of Engelmann spruce, the red fir in such situations forming from 15 to 30 per cent of the stand.

The subalpine fir occurs most abundantly in the lower areas of the subalpine forest. It is always set in mixed stands where it seldom or never exceeds 15 to 28 per cent.

The Engelmann spruce is found abundantly throughout the reserve. While the species here properly belongs to the subalpine-forest type, it occurs lower than 6,000 feet, following the streams in their downward course almost into the plains. In the subalpine forest the spruce commonly occurs in mixed stands and forms from 15 to 45 per cent, occasionally rising to 75 per cent, of the growth, as in the lowest areas of the subalpine forest in the eastern tracts of Hell Roaring Creek Basin. Where the percentage of the species runs high it is always set in old-growth stands.

The composition of the forest is neither normal nor ultimate, but represents a transitional phase due to the numerous fires which have devastated the region for centuries, particularly during the last 200 years. The lodgepole pine is most numerous because here it is a more abundant seed producer, and is better able to adapt itself to the changes in soil and moisture ratio, and probably in chemical composition of the soil caused by the fires. Burned stands, composed in part of red fir and in part of Engelmann spruce, have been replaced by lodgepole pine in areas where it originally formed only a comparatively small percentage. As the lodgepole pine reaches maturity and the stands become more open through natural thinning it will, in course of time, be largely displaced by red fir and spruce.

In the subalpine zone the composition of the forest is more nearly normal than in the areas in which lodgepole pine prevails. The fires have here reduced the percentage of Engelmann spruce, but have not favored the increase of other species, as the burned areas are either grassy or unforested, and the spruce is slowly spreading and eventually, when fully established, will greatly exceed its present percentage in the subalpine forest.

AGE AND SIZE OF TREES.

The greatest diversity prevails in the ages of the trees. Stands 15 to 20 years old are associated with growths 75 to 100 years of age and with veteran stands 200 to 300 years old. This condition has been brought about by fire, the different ages marking burns of different periods. Of the entire forest below the subalpine zone 10 per cent is less than 50 years old, 50 per cent more than 50 and less than 120 years, while the remaining 40 per cent comprises veteran stands from 120 to 300 years of age.

Except in perpetually moist and rich soil the growth of the trees is slow. Limber pine requires one hundred and twenty to one hundred and fifty years to reach heights of 30 to 40 feet, with breast-high diameters of 16 to 18 inches and clear trunks 12 to 15 feet in length. Lodgepole pine in close-set stands averages 70 to 90 feet in length, with breast-high diameters varying from 8 to 12 inches after one hundred to one hundred and fifty years of growth. White-bark pine and other trees of the subalpine forest at high elevations are slow growing. To reach a breast-high diameter of from 10 to 16 inches, and a length of bole from 25 to 45 feet requires one hundred and eighty to two hundred and fifty years. In similar situations Engelmann spruce requires from one hundred to one hundred and twenty years to attain equal dimensions. In moist situations at low or middle elevations Engelmann spruce will reach heights of 50 to 60 feet, with breast-high diameters varying from 16 to 24 inches in one hundred and twenty to one hundred and forty years. The red fir is likewise a slow growing tree, owing to its habitat on dry and rocky soils. It requires from one hundred and twenty to one hundred and fifty years to attain breast-high diameters of 12 to 18 inches, with lengths of bole varying from 60 to 80 feet. With the exception of the lodgepole pine very little timber in the reserve develops any considerable length of clear trunk. Limby and knobby boles with rapid taper and large crowns are the common characteristics. The lodgepole pine, set in close-stocked stands from the first, generally develops long, symmetrical, columnar trunks, although it rarely has a large diameter.

CHARACTER AND VOLUME OF MERCHANTABLE TIMBER.

The timber in the reserve, valuable for commercial purposes, may be divided into two classes: (1) Timber of sufficient dimensions and quality to furnish saw logs, and (2) timber fit only for fuel, fencing, pole, railroad ties, and mine props. The mill timber is present in much the smaller proportion, owing to the preponderance of the lodgepole pine, with its slender, pole-like growth, and the generally low, stocky stature of the other species of trees.

More mill timber is obtained from the lodgepole pine than from any other species, owing to its accessibility and abundance, and to its uniform distribution in areas having the most favorable climatic and soil conditions.

Next in volume comes Engelmann spruce. Although the total volume of the species is less than one-half that of the lodgepole pine the volume of mill timber is nearly 87 per cent of that of the pine, owing to the fact that the spruce of mill-timber dimensions is chiefly an old growth and its yield of saw logs is much greater proportionally than that of the lodgepole pine. Inversely its yield of fuel and pole timber is much less, amounting to only 33 per cent of that of the pine. The spruce is but little used either for mill timber, fuel, or fencing material because the heaviest and best stands of the species occur in localities remote from transportation or demand.

The red fir ranks next in volume. Its mill-timber yield is only 40 per cent of that of the spruce, while its total volume is 55 per cent. Its volume of fuel and pole timber is still more disproportionate, being only 14 per cent of that of lodgepole pine, while its total volume is almost 40 per cent. These variations are due to the fact that only a small quantity of the red fir is found in veteran or middle-aged stands, most of it being very young and unfit for commercial purposes. The red fir is little utilized. Most of it is difficult of access, growing on rocky, steep slopes or remote from transportation, and owing to the stringy and tough character of its timber is not very well liked.

The whitebark pine grows to mill-timber dimensions only in Slough Creek and Hell Roaring Creek bottoms. It has not, so far as is known, been utilized in the region for any purpose, but is included in the estimates because in the localities mentioned it grows to the size required for saw logs.

The white pine forms only an inconsiderable portion of the mill timber. In the Davis Creek region it is easy of access, and would probably have been cut out long ago had the loggers in the West Boulder Valley been able to distinguish the tree from the limber pine, which also occurs nearby and which, in close-set stands, much resembles the white pine.

The yellow pine is of still less volume than the white pine. Owing to its occurrence in the foothills only, it has been logged wherever found, and most of it has been cut out. The climatic conditions and its general altitude are inimical to the growth and extensions of the yellow-pine stands.

The yield of the mill timber varies from less than 1,000 feet B. M. per acre in the higher areas and in the tracts adjacent to the foothills to 10,000 feet B. M. on the tracts embraced in the bottoms of Davis Creek and middle West Boulder River, the Slough Creek bottoms, and portions of Buffalo Creek Valley. The highest yield observed anywhere was in the lower subalpine areas on the east side of Hell Roaring Creek Basin, where small tracts with veteran stands of nearly pure growth Engelmann spruce carry from 20,000 to 25,000 feet per acre. The diametral dimensions of the mill timber are small unless the logs are cut from Engelmann spruce, which will yield logs from 14 inches to 2 feet in diameter when squared. Logs from other species are much smaller, the average for the reserve being scarcely above 10¼ inches squared, and running from 10 to 15 logs per 1,000 feet B. M.

The yield of pole and fuel timber is comparatively large, owing to the close-set character of the lodgepole-pine stands, which furnish more than 50 per cent of the total volume. The yield of the subalpine forest zone is also considerable, when the generally open character of much of the growth on these areas is considered. This is owing to the preponderance of old growth in this type of forest, which often gives a larger volume of wood on an equal area than do the closer set but less advanced stands at lower elevations. The quantity per acre of pole and fuel timber varies from 500 to 900 cubic feet for the thinnest and most scattered subalpine stands to 3,000 and 4,000 cubic feet for the closely stocked, middle-aged lodgepole-pine forest. In some of the very heavily stocked areas in Slough Creek and Hell Roaring Creek basins the amount rises to 10,000 cubic feet per acre. With the exception of Slough Creek and Hell Roaring Creek basins little of the area carries fully stocked stands. Notwithstanding rocky and comparatively barren soil, the region will be capable of sustaining at least twice the volume of timber it now does, if fires are totally suppressed, grazing and cutting restricted, and sheeping absolutely prohibited.

The total volume of mill timber in the Absaroka division, estimated on the minimum basis of 8 inches in diameter, breast high, and 10 feet of available bole, with the proportions furnished by each species, is as follows:

Volume of mill timber in Absaroka division of Yellowstone Forest Reserve.

	Feet B. M.
Limber pine	1,000,000
Lodgepole pine	434,000,000
Yellow pine	980,000
White pine	3,550,000
White-bark pine	8,000,000
Red fir	147,950,000
Subalpine fir	1,000,000
Engelmann spruce	376,200,000
Total	972,680,000

This gives an average stand slightly in excess of 2,190 feet B. M., per forested acre.

The volume of pole and fuel timber in the Absaroka division of the reserve, including the woodlands, is as follows, basing the estimates on diameters not less than 4 inches, breast high:

Volume of pole and fuel timber in the Absaroka division of the Yellowstone Forest Reserve.

	Cubic feet.
Limber pine	11,235,000
Lodgepole pine	511,900,000
Yellow pine	1,440,000
White pine	300,000
White-bark pine	82,230,000
Red fir	76,200,000
Subalpine fir	112,050,000
Engelmann spruce	155,100,000
Aspen and cottonwood	2,100,000
Total	952,555,000

The average volume of pole and fuel timber is nearly 2,000 cubic feet per acre. Counting 180 cubic feet of timber equal to 1,000 feet B. M., the average stand is raised to 2,390 cubic feet per timbered acre.

CUTTING.

The logged and culled areas comprise 41,650 acres, of which 22,000 acres are forested tracts and 19,650 acres are woodland. Probably all or a greater portion of the woodlands, 37,200 acres, have been more or less culled during the last thirty or thirty-five years, but many of the traces of the early cutting are now obliterated. Except in the areas adjacent to upper Boulder River the cutting is confined to the north, east, and south edges of the area discussed. Most of the cutting has been for the purpose of obtaining mine props, fuel, and fencing material. A smaller quantity has been used for railroad ties and burned for charcoal.

In the valleys of Boulder and West Boulder rivers, 50 to 90 per cent of the sizable red fir, spruce, and lodgepole pine was cut in 1882 or 1883, or possibly in 1881. The cutting extended south from the north line of the reserve up the West Boulder 2 or 3 miles and up the Boulder 10 or 12 miles, while comparatively little timber appears to have been taken out of the valley of the East Boulder. Cutting also took place on Boulder River near its head and is still actively carried on. In addition to this, a small sawmill is now established a few miles below the former camp of Independence. A small sawmill is established in the valley of the East Boulder, about 3 miles south of the north line of the reserve, and another in the middle Stillwater drainage in T. 5 N., R. 15 E. These mills are small and as yet have made little inroads on the forests in their respective localities. From the East Boulder, skirting the foot of the range around to the Rocky Fork drainage the forest has been cut and culled from 10 per cent to total. The cutting has been confined to a narrow strip and is not in a continuous belt. A large portion of the timber taken here within the past six or seven years had been fire killed. In the Rocky Fork Creek drainage the cutting area extends 3 to 4 miles up the two forks of the stream. A great deal of timber has been taken for mine props in the coal mines at Red Lodge, for fencing and fuel for the ranchers, and for cordwood for the lime burners in T. 8 S., Rs., 19 and 20 E. Here much of the timber cut had been fire killed.

Around Cooke City in T. 9 S., Rs. 14 and 15 E. 7,000 acres have been logged or culled, the cut varying from 10 per cent to total. The cutting was for the purpose of supplying mining timber to the various properties around Cooke City, fuel to stamp mills which formerly milled the ores of that region, and charcoal to one or two small smelters which have long since ceased operations. Very little cutting is going on there at present, merely enough to supply fuel to Cooke City and timber to the few miners doing assessment work. In the southwest corner of the area discussed, in the Crevice district, there has been some cutting for mining timbers and fuel, but the cut has been small. Various other tracts in the reserve have been cut over and culled, but the total amount removed has been insignificant. The large body of the forest at middle elevations and nearly all of the subalpine stands have not been touched by the ax.

No attempt has been made to leave the cut-over area in clean condition. There has been no piling of tops, except on the areas cut over since the ranger patrol of the General Land Office was established. However, much of the cut-over area, in the Boulder drainage especially, has been burned over and the tops and limbs thus removed. In general the cutting itself has caused no particular damage to the forest floor nor to the young growth. Most of the cut timber consisted of lodgepole pine, and owing to its abundant and rapid reproduction the logged tracts, where not run over by fire, are promptly restocking. There is one exception to the rule noted, namely, at Cowles mining camp near Haystack Peak. This camp is only 700 or 800 feet below timber line. The supply of timber in the immediate vicinity is limited, while the consumption, although not rapid, is constant. Here the steep hillsides are being totally denuded by the choppers and, with the limited and slow restockage of the subalpine forest, a long time must elapse before new stands replace those now being cut.

Most of the timber is exceedingly difficult of access and can only be taken out of the reserve with much labor and expense. Except for local use, or unless means of transportation through the National Park are provided, so as to reach the heavy stands in Slough Creek and adjacent basins, the bulk of the forest will remain uncut for a century or more. Boulder and Stillwater rivers and Rocky Fork Creek are drivable during high water, but these streams are sunk in deep, rocky canyons, and the amount of timber accessible by way of them is small.

BURNS.

The areas burned over during the last thirty-five or forty years aggregate 138,410 acres. The tracts are of varying extent and occur in all portions of the area, but more particularly in the northwest quarter, in the Boulder, Rosebud, and Rocky Fork drainage basins. They are of smaller extent in the southern third of the area, although by no means wholly lacking.

As far back as its history can be traced the forest has been more or less devastated by fires, its age and composition proving that these were very common and of wide extent during the Indian occupancy of the region. The large preponderance of lodgepole pine, is wholly the result of these fires, the great complexity and variation in the age of the stands indicating successive ones during centuries. Not less than 70 per cent of the forest land has been burned over within the last one hundred and twenty years, showing that since the coming of the white man there have been more fires than when the Indian held possession. In the last twenty-two years 24 per cent of the forest area has been burned, while during the one hundred and thirty years preceding about 45 per cent was swept by fire.

The forest fires in this region are remarkable for their destructive force and intensity. Here and there are uneven aged stands, where extremes in age and a mixed composition prove that occasionally the fires did not consume or kill the entire stand. But as a rule most of the older fires made a clean sweep, and in nearly every instance the fires of modern date have done the same.

The destructiveness of the fires is due to the great quantities of litter which accumulate during the process of natural thinning, and also, to a lesser extent, to the character of the ground cover. Duff, or humus, is nearly lacking, except on a few of the northern slopes, and plays no particular part in the spread and intensity of the fires. The general ground cover consists of moss, usually a thin layer 2 or 3 inches in depth, a slight sprinkling of pine needles, low shrubs, mostly species of huckleberry, and more or less of a grassy turf or sward. During the dry season all this material burns readily, but does not make a hot or high flaming fire. It is different with the litter. The great mass of dry or partly dry wood of which it is composed makes hot and flaming fires, consuming or killing all live timber. The litter is derived in part from unconsumed débris left behind after previous fires, and in part from trees killed by excessive stockage and consequent overcrowding. The dense stockage is a sequel to fires and one of the phases of reforestation. When a tract of forest situated below the upper subalpine areas between the 8,000 and 6,500 foot levels is destroyed by fire lodgepole pine almost always follows as the primary restockage in at least 98 per cent of the cases. It is always set exceedingly close, having 10 to 20 seedlings to a square foot of ground in favorable situations. The close-set trees develop long, slender shafts, and as the stand becomes older the natural process of thinning begins. The final result is that when the stand reaches 80 to 100 years in age it is filled with long, slender dead trees, and is a veritable tinder box. Most of the stands of the ages mentioned are choked with such accumulations of dead and fallen timber. Further additions to the inflammable material are furnished by the wreckage of the former forest, as often in a forest through which fire has run there is left standing a mass of seasoning timber, although every tree may be killed. Gradually the fire-killed trees are thrown down by the wind, forming great tangled masses of kindling wood for future fires to feed on. All of the destructive fires of recent years appear to have originated, or at least to have gained headway, in the débris that litters the close-set lodgepole-pine stands, and as these constitute the great mass and hence the most valuable portions of the forest, they need to be particularly guarded.

RESTOCKAGE.

In the subalpine areas young growth is almost everywhere scanty, whether as restockage after fires or as the ordinary renewals in the growing forest. The grassy openings made by fires during the Indian occupancy are very slowly giving way to a young growth of spruce and white-bark pine. A potent cause for the scantiness of the young growth in the subalpine forest is the low ratio of cone and seed production, characteristic of all subalpine trees when growing at high elevations. Some of the species, as the white-bark pine and subalpine fir, do not readily bear cones nor mature their seeds at any altitude in this region, and as most of the subalpine tracts are situated well above the limits of growth for the lodgepole pine, this tree, with its abundant seed production, does not become a factor in the restockage. The most prolific of the subalpine trees is the spruce, which in time is bound to form the larger proportion of this type of forest, and will be followed by the subalpine fir as taking second rank. The great snow banks, which each season pile up at these altitudes, likewise hinder restockage, as they bend and break multitudes of young trees beyond recovery.

The uppermost line of forest presents a ragged and wavy line, apparently advancing and receding from time to time, but there are no very definite indications of any change in the altitudinal limits of the general timber line within the life of the present forest. If any changes are now taking place they are wholly in the direction of an upward movement—that is, there is a tendency toward higher mean temperatures and less precipitation in the subalpine and alpine areas, with corresponding elevation of the timber line.

In the great mass of the forest between the low levels occupied by the woodlands and the subalpine zone reproduction is abundant where not interrupted by repeated fires over the same area. In the veteran stands where the composition of the forest approaches normal—that is, a preponderance of Engelmann spruce at the upper and intermediate levels and of red fir at the lower, young growth is present in sufficient quantities to maintain the density of the stands and their present composition. In the veteran stands composed of lodgepole pine young spruce and red fir are gradually regaining ground that they formerly occupied. In young and middle-aged stands the lodgepole pines are set so close that there practically can be no additions of any other species. The restockage on ground denuded by fire is nearly always composed of lodgepole pine, unless the tract is situated at low elevations where well-advanced growths of red fir prevailed on adjacent areas and lodgepole pine formed but a small percentage. In such cases the young growth is chiefly red fir. On tracts denuded by logging operations mixed stands composed of red fir, spruce, and lodgepole pine are apt to come in from the first, even if the pine forms the larger proportion of the surrounding forest. In some cases, at the lowest altitudes, aspen comes in and forms extensive and long persistent growths, whether the tract was denuded by fire or cut. The general rule, however, is that where openings are made in the forest either by fire or ax between altitudes of 6,400 and 7,900 feet, the species of inferior value, here the lodgepole pine, will form by far the largest percentage of the restockage, and will continue to occupy the ground until, in the process of natural pruning and thinning, the more valuable and less tolerant red fir and spruce succeed in reestablishing themselves.

Openings made by fire are always more favorable to a larger per cent of lodgepole pine in the restockage than is the case where cutting has thinned or destroyed the stands. The cause for this is principally the destruction of the cover in the former case and its conservation in the latter, affording a proper germinating layer or seed bed for the seeds of the red fir and spruce, which in this region apparently need some such cover. Where fire destroys a restockage growing on a tract burned over fifteen or twenty years previously, some changes occur in the soil extremely inimical to any subsequent reforestation. Tracts of this sort are likely to become brush covered, and a decade or two may pass before forest growth again appears on them. Burns of this sort occur in the northwest and northeast quarters of the area. The common brush growth in such cases is composed of *Ceanothus velutinus* and *Shepherdia canadensis.*

Reproduction in the woodland areas is slow and sparse as a rule. The heavy grass cover more or less prevents germination of seeds of the coniferous trees composing the stands, and none of these species is at all prolific in seed production in this region. Exceptions to the general scarcity of seedling and sapling growth in the woodlands occur in T. 7 S., R. 18 E. Here tracts, formerly grass covered and aggregating 9,000 or 10,000 acres, have within the last thirty or thirty-five years been transformed from woodland to forest, with close-set stands of lodgepole pine and aspen, which have spread out from the forested mountain region in the township adjoining on the south.

TOWNSHIP DESCRIPTIONS.

IN THE ABSAROKA DIVISION.

Township 2 South, Range 14 East.

Topography.—The central and eastern portions of this township comprise masses of very steep and broken ridges, with an altitudinal range between the 5,000-foot and the 6,000-foot contours. In the extreme northern and in the western areas the ridges sink into a rolling foothill country intersected by numerous shallow ravines. The township forms the extreme northern end of the Yellowstone Forest Reserve, and its system of ridges and spurs represent the northern termination of the great mountain masses which constitute the eastern portion of the Boulder drainage in the central areas of the Absaroka division.

Mining.—None.

Soil.—Here and there in the valleys the soil is a gravelly loam. In some places it consists of clay and gumbo.

Agricultural adaptability.—Along the west line of the township in the Deer Creek drainage there are small tracts of tillable land. In general the region is much too rough and rolling to be cultivable, and lacks water for irrigation.

Grazing capacity.—The western and northeastern areas, composed chiefly of thinly stocked woodlands or of tracts devoid of trees, are suitable for stock ranges. Portions have long been used as sheep runs and have been more or less badly overgrazed

Drainage conditions.—The outflow originating in the township is of small volume, and is carried by upper Deer Creek. Most of the runs and ravines are dry during summer and fall.

Towns and settlements.—None.

Forest conditions.—The forest is composed of red fir, limber pine, and lodgepole pine, red fir being the prevailing species. On the northern slopes the stands are set close; elsewhere they are thin and scattering. Fifty per cent of the forest consists of young sapling stands—reforestations after fires that burned thirty to fifty years ago. The timber is difficult of access.

Woodlands.—The woodlands comprising the foothill region or tracts below the 5,500-foot contour carry a thin and scattering growth of limber pine, yellow pine, red fir, aspen, and cottonwood. The growth possesses only a fuel value.

Cutting.—Small quantities have been culled for farm use in various places along the north and west lines.

Burns.—Six or eight years ago extensive fires in the central portion of the township laid waste large blocks of red fir and lodgepole pine, and destroyed most of the standing timber on the tracts burned over.

Reproduction.—Reforestation is scanty on the more recent burns. The tendency is toward brush growth instead of timber. Red fir is the prevailing species in the restockage. On tracts burned over thirty or forty years ago close-set stands of red fir are coming in abundantly.

Undergrowth.—Light.

Litter.—On the burned-over tracts litter of dead and fallen and partly consumed timber is abundant; elsewhere there is little of this material.

Humus.—None.

Classification of lands in T. 2 S., R. 14 E.

	Acres.
Forested	9,540
Wooded	5,700
Nontimbered	7,800
Badly burned	3,800
Logged	None.
Agricultural	1,000
Grazing (including woodlands)	8,700
Bare rocks	1,000

Total stand of timber in T. 2 S., R. 14 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B.M.	*Cubic feet.*	*Cubic feet.*
Limber pine		3,000,000	3,000,000
Lodgepole pine		3,000,000	3,000,000
Yellow pine	800,000	500,000	644,000
Red fir	9,000,000	5,000,000	6,620,000
Engelmann spruce	550,000	400,000	499,000
Total	10,350,000	11,900,000	13,763,000

Composition of forest in T. 2 S., R. 14 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	15
Lodgepole pine	25
Yellow pine	.3
Red fir	56.7
Engelmann spruce	3

TOWNSHIP 3 SOUTH, RANGE 10 EAST.

Topography.—The portion of this township within the limits of the reserve has an area of 15,360 acres, consisting mostly of extremely steep, rough, and rocky crests, peaks, and slopes with deep and narrow intervening canyons. On the north and west the township is bordered by the levels of the Yellowstone Valley, from which, beyond an intermediate narrow strip of broken foothill region, the mountainous areas rise with steep, bold fronts to elevations of 10,000 feet. The summits of the ridges generally are narrow, and together with the upper slopes and their numerous precipitous rock escarpments, show everywhere deeply fissured, rapidly crumbling strata.

Mining.—None.

Grazing capacity.—The grazing areas of the township at the lower elevations consist of small parks and openings, scattered glades at the heads of the [illegible] [illegible] grass- or sedge-covered ridges at or above timber line, and tracts temporarily [illegible] [illegible] by recent fires; in all, 800 acres.

Agricultural adaptability.—No portion of the township is suitable for agri[illegible] [illegible]. The valleys are too narrow and stony, the [illegible] too [illegible] [illegible] and, in general, the elevation too high.

Soil.—Generally thin, stony, and bowlder-strewn thro[illegible]

[illegible] water-holding capacity. The higher areas [illegible] the township shed [illegible] of water, many of the high northern slopes [illegible]ing snow throughout [illegible]

the summer. Much of the precipitation, however, is lost in the talus and débris which litters the valley bottoms and the slopes. The chief drainage channels are Deep, Suce, and Mission creeks, the waters of which are more or less utilized for irrigation purposes.

Towns and settlements.—None.

Forest conditions.—The forest generally is thinly stocked, with the exceptions of lodgepole-pine stands at middle elevations and small tracts of mixed growth along northern slopes bordering Mission Creek in its upper and western portions. Fifty per cent of the forest is composed of young growth 30 to 50 years old—reforestations after fires which burned that long since. All the slopes directly fronting on the Yellowstone Valley up to 7,000 feet bear stands composed of red fir to the extent of 95 per cent, mostly of the common, slender, eastern Montana type. The forest in the upper portions of the canyons and on the higher slopes is composed of stands of lodgepole pine, often 95 per cent pure, alternating with mixed stands of subalpine fir and Engelmann spruce, all of small size, even when of mature growth. The forest along the high crests and near timber line consists of more or less scattered trees of subalpine fir, white-bark pine, and Engelmann spruce, stocky and stunted in growth. As a whole the forest in the township is too small for mill timber, and is valuable chiefly for fuel, and most of all for the stability it imparts to the steep, loose, crumbling, and sliding mountain slopes that make up the larger portion of the township. All of the timbered areas are difficult of access.

Cutting.—Small quantities have been cut here and there on upper Suce and along the middle areas of Mission Creek.

Burns.—Burns have been frequent and extensive, both in past and in present times. All the young growth 30 to 50 years old, both of lodgepole pine and of red fir, as well as the old and mature, pure-stand, lodgepole-pine growths, mark clean-burning fires of various ages. The burns of recent times, swept clean of forest and not yet restocking, aggregate 3,800 acres.

Reproduction.—Reproduction is slow and deficient on all the recently burned-over ground and also throughout the thin and scattered subalpine forest. On areas burned over forty to sixty years ago young growth is abundant and is composed of red fir and lodgepole pine, set close and fully stocking the ground. In the mature, or partly mature, forest young growth is present in moderate quantities, sufficient to maintain the present density of stands.

Undergrowth.—On the burned-over slopes, which are not yet reforesting, brush growths composed chiefly of *Ceanothus velutinus* are abundant. In the close set sapling stands of red fir and lodgepole pine undergrowth is practically lacking. Throughout the older forest there is a moderate amount of scattered undergrowth composed of juniper scrub, alders, willows, and mountain ash.

Litter.—Abundant except in the subalpine areas. It consists of dead and down timber, in part the unconsumed débris remaining after fires and in part trees killed by crowding in the close-set lodgepole pine stands.

Humus.—None, or at the most a thin topping of moss and pine needles in the older forest.

Snow and rock slides.—Frequent throughout all of the higher areas of the township, as shown by the accumulations of débris in the bottom of the canyons.

Classification of lands in T. 3 S., R. 10 E

	Acres.
Forested	6,560
Nonforested	8,800
Badly burned	3,800
Logged (culled)	250
Agricultural	None.
Grazing	1,000
Bare rocks	4,000

Total stand of timber in T. 3 S., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	1,600,000	4,500,000	4,788,000
White-bark pine		800,000	800,000
Red fir	1,200,000	2,000,000	2,216,000
Subalpine fir		800,000	800,000
Engelmann spruce	2,600,000	550,000	1,018,000
Total	5,400,000	8,650,000	9,622,000

Composition of forest in T. 3 S., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	[illegible]
Red fir	[illegible]
Subalpine fir	[illegible]
Engelmann spruce	[illegible]

TOWNSHIP 3 SOUTH, RANGE 11 EAST.

Topography.—All of the township with the exception of the northeast quarter and a portion of the southeast quarter consists of a rough, deeply sculptured mass of mountains, which in the most elevated portions attains altitudes of nearly 10,000 feet. The ridges and spurs are narrow, rocky, steep, and precipitous, crowned with serrated and pinnacled crests. The canyons, generally contracted and cliff-bound, are littered with great accumulations of bowlders. The northeast quarter of the township comprises a rolling foothill region, in which narrow creek valleys and swales separate long easterly and westerly combs and ridges. The southeast corner of the tract is chiefly comprised in the valley of West Boulder River, a depression 600 to 700 feet below the summits of the inclosing ridges, here broad and open, but near the south line of the township contracting into a canyon.

Mining.—None.

Soil.—Throughout the mountain areas the soil is thin and stony, and the surface is littered with bowlders. In the foothill region in the northeast quarter of the township the swales and creek bottoms have a deep, rich, loamy soil, while the ridges generally are stony and strewn with great masses of bowlder drift. The bottom lands in West Boulder River have a thin, loamy soil, resting on clear gravel and boulder drift.

Agricultural adaptability.—The swales and creek bottoms in the foothill region and the bottom lands in West Boulder Valley are agricultural in character and are occupied and in cultivation wherever irrigation is possible. The mountain areas contain no agricultural lands.

Grazing capacity.—All of the northeast quarter of the township that is not susceptible of tillage and that does not bear forest is grazing land. Small tracts of grass land also occur in the valley of the West Boulder and as scattered glades along the creek bottoms throughout the mountain areas. In the aggregate the grazing lands comprise 3,500 acres.

Drainage conditions.—The run-off is abundant. Small pools and springs are numerous at the heads of the canyons. Many of the high northern slopes hold banks of snow throughout the year. Much of the run-off sinks and is lost in the steeply upturned and deeply fissured limestone strata of the region, and in the vast morainic accumulations in the larger canyons. Where conditions are favorable the streams are utilized for irrigation purposes.

Snow and rock slides.—Common and frequent at all seasons. Enormous masses of overhang, mostly fissured and rapidly crumbling, occur all along the higher summits, while the talus slopes are loose and sliding on substrata of wet, clayey mud.

Towns and settlements.—There are no towns. Settlers are living on the cultivated areas in the northeast quarter of the township and in the West Boulder Valley up to the south line of the township.

Forest conditions.—With the exception of the lower areas in the canyon of Davis Creek, a tributary of the West Boulder entering along the south line of the township, the forest is composed of stands thinly stocked, in so far as relates to the mature forest. Small tracts of the slopes adjacent to the foothill region carry moderately well-stocked stands of sapling red fir, which is the prevailing species in all the lower areas of the northern portion of the township. The foothill region is sparsely stocked with scattering stands of this species along the creek bottoms and on northern slopes of the combs and ridges. In the interior portions of the township lodgepole pine, Engelmann spruce, and subalpine fir form the forest in the valley bottoms and at middle elevations. At higher altitudes the lodgepole pine thins out and is replaced by white-bark pine. The forest is much broken and irregular, owing to the many small burns and bare rocky expanses devoid of soil that occur everywhere in the region. All ages of growth are represented, from pole stands 30 to 40 years old to mature stands 150 to 200 years old. One-fourth of the forest is less than 100 years old. The heaviest stand, and the most prolific in mill-timber dimensions, occurs in the Davis Creek bottoms along the south line of the township. It yields from 5,000 to 10,000 feet B. M. to the acre and is composed principally of red fir 120 to 175 years old, with small proportions of spruce and the western white pine (*Pinus monticola*).

Cutting.—The stands in West Boulder Valley were cut and culled 75 per cent at the time of the Northern Pacific Railroad construction to furnish tie timber. Small areas in the foothills have also been cut over to supply local demands for fuel and poles.

Burns.—Small areas of burns, 6 to 20 years old, are scattered throughout the forest. The largest tracts of burned forest are situated in and contiguous to West Boulder Valley. They comprise in the aggregate 3,200 acres, and are practically clean burns, all the timber having been either consumed or killed.

Reproduction.—Reproduction is slow and deficient on all the higher slopes and summits. It is moderate at middle elevations except on the burns, where, outside of West Boulder Valley, there is little or no young growth. On the burns where restockage has begun lodgepole pine is the leading species. In the foothill region and on the slopes fronting on those areas red fir is the predominating species. In the mature forest there is a moderate amount of young growth composed of the same species which form the old growth.

Undergrowth.—The undergrowth is scanty. It is composed of willows, alders, juniper scrub, and the like.

Litter.—Litter is abundant in the more vigorous and close-set stands; elsewhere there is little. It is chiefly composed of the unconsumed débris from former fires and of trees killed by overcrowding.

Humus.—On northern slopes a thin cover of moss and pine needles.

Classification of lands in T. 3 S., R. 11 E.

	Acres.
Forested	10,160
Nonforested	12,880
Badly burned	3,200
Logged	1,600
Agricultural	1,800
Grazing	3,500
Bare rocks	4,380

Total stand of timber in T. 3 S., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		80,000	80,000
Lodgepole pine	1,500,000	1,800,000	2,070,000
White pine	500,000	300,000	390,000
White-bark pine		500,000	500,000
Red fir	21,000,000	12,000,000	15,780,000
Subalpine fir		4,000,000	4,000,000
Engelmann spruce	6,500,000	5,000,000	6,170,000
Total	29,500,000	23,680,000	28,990,000

Composition of forest in T. 3 S., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	0.2
Lodgepole pine	10.8
White pine	.1
White-bark pine	3.9
Red fir	62
Subalpine fir	15
Engelmann spruce	10

TOWNSHIP 3 SOUTH, RANGE 14 EAST.

Topography.—This township comprises a mass of steep, precipitous spurs and ridges rising to altitudes of 7,200 feet, which mark the northern terminations of the mountains of the Boulder drainage. It is drained partly by Deer Creek, and partly by East Boulder River.

Mining.—None.

Soil.—Gravelly loam, clayey and gumbo-like in places.

Agricultural adaptability.—None.

Grazing capacity.—Small tracts in the western areas, chiefly deforested hillside, are grassed over and furnish limited areas of pasturage.

Drainage conditions.—The run-off at the time of the spring break-up is large, but, owing to the very steep and broken character of the region, does not last long. During the summer the creeks and rivulets heading in the tract are either dry or carry only an insignificant amount of water.

Snow and rock slides.—Frequent in the central areas of the tract.

Towns and settlements.—None.

Forest conditions.—The stands are very much broken and scattered owing to the rocky ground and the extensive fires that have invaded the region. The higher areas bear stands of lodgepole pine, mostly in the sapling stage. At middle and lower elevations red fir is the leading species, 50 per cent of the timber being sapling growth.

Woodlands.—The southeast and the northwest corners of the township are lightly stocked with timber and constitute woodland. The growth consists of limber pine, scattered yellow pine, and copses of red fir.

Cutting.—None.

Burns.—Extensive fires have run throughout the central and western areas. They date back six or seven years, and have destroyed all of the timber on the areas where they burned.

Reproduction.—Deficient on the burned-over areas; abundant elsewhere. Red fir predominates in all the young growth.

Undergrowth.—Scanty.

Litter.—Abundant on the burned-over ground.

Humus.—None.

Classification of lands in T. 3 S., R. 14 E.

	Acres.
Forested	7,060
Wooded	2,800
Nontimbered	13,180
Badly burned	9,500
Logged	None.
Agricultural	None.
Grazing	1,680
Bare rocks	2,000

Total stand of timber in T. 3 S., R. 14 E.

Species.	Mill timber.	Pole and fuel timber	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	[illegible]
Limber pine		1,300,000	1,300,000
Lodgepole pine		1,500,000	1,500,000
White-bark pine		300,000	300,000
Red fir	12,000,000	4,000,000	6,1[illegible]
Engelmann spruce	300,000	100,000	1[illegible]
Total	12,300,000	7,[illegible]	[illegible]

Composition of forest in T. 3 S., R. 14 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	8
Lodgepole pine	35
White-bark pine	1
Yellow pine	Scattered trees.
Red fir	53
Subalpine fir	.2
Engelmann spruce	2.5
Aspen and cottonwood	.3

TOWNSHIP 3 SOUTH, RANGE 15 EAST.

Topography.—This township comprises a tract of country situated at the head of Bridger and lower Deer creeks and forms the termination of one of the long northerly spurs which stretch out from the great mountain masses in the Boulder drainage to the south. It possesses a very rough relief, the entire township, with the exception of a narrow strip along the east line, being a succession of steep, rocky ridges and narrow, cliff-bound canyons. The altitude varies from 5,600 to 7,000 feet.

Mining.—None.

Soil.—Gravelly and clayey loam.

Agricultural adaptability.—The township contains no tillable land owing to its exceedingly rough surface.

Grazing capacity.—The southeastern and northern areas are in part well grassed and have long been used as pasture grounds, chiefly for cattle, and, to a lesser extent, for sheep. The pasturage is mostly bunch grass and has not been seriously overgrazed in any locality.

Drainage conditions.—The outflow from the township is carried by Bridger and lower, or East Deer, creeks. The multitude of runs and ravines which intersect the tract are mostly dry throughout the greater part of the year. The total run-off on the areas embraced within the tract is of insignificant volume.

Snow and rock slides.—Not infrequent in the central portions of the tract along the steep slopes of lower Deer Creek.

Town and settlements.—None.

Forest conditions.—The forest consists of red fir and limber pine at lower elevations with tracts of lodgepole pine at the highest altitudes. In general the stands are thin, and are scattered as copses of varying extent over the rocky slopes. Here and there at the head of Bridger Creek and in the middle areas of the Deer Creek drainage are a few close-set stands of red fir. The red fir growth is largely composed of mature stands, while the lodgepole pine is chiefly in the pole and sapling stage.

Woodlands.—The extreme eastern and parts of the northern areas are thinly stocked with red fir and limber and yellow pine, and constitute woodlands. Climatic conditions in part, but chiefly often repeated fires during the Indian occupancy of the region, are the causes of the thinly stocked conditions of the woodlands. Most of the area is capable of supporting moderate stands of forest.

Cutting.—Small areas along Deer Creek in the northern portion of the township have been cut over to supply local demands.

Burns.—The burned-over tracts are mostly confined to the southwest quarter of the township in the lodgepole pine stands, and are eight to ten years old. The destruction of timber on them has been complete.

Reproduction.—Scanty in the woodlands and in the lodgepole pine growths as well as on the burned-over areas. Young growth is abundant in the red-fir stands, and is composed almost wholly of this species.

Undergrowth.—Very light.

Litter.—Abundant on the burned-over tracts; little in other localities.

Humus.—None.

Classification of lands in T. 3 S., R. 15 E.

	Acres.
Forested	11,040
Wooded	3,800
Nontimbered	8,200
Badly burned	3,000
Logged (culled)	600
Agricultural	None.
Grazing	4,200
Bare rocks	1,000

Total stand of timber in T. 3 S., R. 15 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	1,000,000	3,000,000	3,180,000
Lodgepole pine	2,000,000	6,000,000	6,360,000
Red fir	10,800,000	5,500,000	7,444,000
Engelmann spruce	500,000		90,000
Total	14,300,000	14,500,000	17,074,000

Composition of forest in T. 3 S., R. 15 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	10
Lodgepole pine	35
Red fir	53
Engelmann spruce	2

Township 4 South, Range 10 East.

Topography.—This township comprises high, rough mountains rising to elevations of 10,000 feet, abounding with precipices and sharp declivities. The summits are rocky, fissured, and crumbling, and the canyons are narrow and littered with talus accumulations and débris swept down from the mountain sides by avalanches and landslips. Only 21,120 acres of this township are within the reserve, three sections, or 1,920 acres, in the northwest corner being excluded.

Mining.—None.

Soil.—All of the soil, except a thin top-dressing of loam, is derived from hard, granitic rocks and is highly siliceous and sterile. It rests on gravel and bowlders.

Agricultural adaptability.—The steep slopes, rocky and sterile soil, and high altitude render the land unfit for agriculture.

Grazing capacity.—The township has no grazing value.

Drainage conditions.—There is a large run-off from the high areas of the township, but most of it is absorbed or sunk in the talus and morainic débris of the lower slopes and valleys, and comparatively little reaches the levels of the Yellowstone Valley. The waters of the streams flowing from the western areas of the township are used to some extent for irrigation in the Yellowstone Valley.

Snow and rock slides.—Avalanches of snow and rock are of frequent occurrence throughout all the higher areas.

Towns and settlements.—The township is uninhabited.

Forest conditions.—The forest consists of thin stands of white-bark pine, Engelmann spruce, and subalpine fir, scattered among the breaks of the slopes and around the heads of the canyons, while in the valley bottoms lodgepole pine, chiefly a sapling growth thirty to forty years old, forms the prevailing timber. Red fir occurs on the lower and warmer slopes of the western areas. Most of the timber is situated in inaccessible places and has only a fuel value.

Cutting.—Small quantities have been cut in the western areas for farm use in the Yellowstone Valley.

Burns.—The burns are confined to the western areas and aggregate 1,800 acres.

Reproduction.—The reproductive capacity of the subalpine forest is low. In the lodgepole pine stands at middle and lowest elevations young growth is abundant and vigorous. The burns are restocking chiefly with lodgepole pine in place of the former red fir and spruce.

Undergrowth.—Brush growth is moderately abundant except in the subalpine forest, where it is light or lacking. It consists of cherry, juniper, juneberry, *Ceanothus*, and huckleberry of several different species.

Litter.—In the lodgepole-pine stands litter is abundant. It consists of dead and down timber, partly the result of past fires, and partly of trees killed by overcrowding in the too close-set stands.

Humus.—Lacking, or a thin moss cover, on the northern slopes.

Classification of lands in T. 4 S., R. 10 E.

	Acres.
Forested	8,900
Nonforested	12,220
Badly burned	1,800
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and alpine	10,420

Total stand of timber in T. 4 S., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	2,000,000	6,000,000	6,360,000
White-bark pine		430,000	430,000
Red fir	2,000,000	3,000,000	3,360,000
Subalpine fir		1,800,000	1,800,000
Engelmann spruce	500,000	2,000,000	2,090,000
Total	4,500,000	13,230,000	14,040,000

Composition of forest in T. 4 S., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	65
White-bark pine	2
Red fir	20
Subalpine fir	9
Engelmann spruce	4

TOWNSHIP 4 SOUTH, RANGE 11 EAST.

Topography.—The western part of the township comprises a rugged mass [illegible] mountains—a portion of the main divide of the Absaroka Range. The central areas are cut by the narrow and cliff-bound trough of West Boulder Cañon, while the eastern portion consists of an elevated block of granite known as West Boulder Plateau, which rises to an altitude of nearly 11,000 feet, and has a broad undulating surface littered with great fields of bowlders. The plateau breaks off on the east and west by sheer descents, 1,000 to 1,500 feet in depth, while short, bowlder-littered canyons cut into its sides between immense, precipitous walls of rock.

Mining.—None.

Soil.—Stony and gravelly glacial débris, with thin top-dressings of loam.

Agricultural adaptability.—None; the mountainous and elevated character of the region makes agriculture an impossibility.

Grazing capacity.—A number of wet meadows and glades in the West Boulder Canyon are adapted to grazing purposes. The summit of West Boulder Plateau is covered with alpine sedges and grass and can be pastured, although access is difficult.

Drainage conditions.—The tract has a large outflow. Springs, marshy tracts, rivulets, and creeks are numerous. Small ponds occur here and there. A large quantity of the outflow sinks in the talus slopes and glacial litter that lie in the valley of the West Boulder, and does not reappear either in the township or outside.

Towns and settlements.—The township contains no settlements.

Forest conditions.—The eastern areas carry no forest on the summit of West Boulder Plateau and only a thin subalpine growth along the upper line of breaks. In the valley the stands are composed of thickset lodgepole pine, with spruce and red fir, the latter reaching a height of 100 feet and a diameter of 3 feet. The stands in the extreme northeast corner consist chiefly of 25 to 30 years old lodgepole pine. The western areas of the township are in part situated above timber line, and in part bear thin, scattering stands of subalpine species. The bottoms of the West Boulder are not difficult of access and much of the timber standing there can be floated down the stream during high water. The timber on the higher slopes can not readily be reached.

Cutting.—In the West Boulder Valley, near the north line of the township, the timber on 1,800 acres was culled 60 per cent by tie cutters in 1882–83.

Burns.—Severe burns visited portions of the tract in 1882–83 and at intervals since that time. The burns are confined chiefly to the northern portion of the township, where they occur on the slopes of West Boulder Plateau, near the outlet of Davis Creek and along the west bank of Boulder River.

Reproduction.—There is as yet no restocking of the burned-over areas near Davis Creek nor on the higher slopes of West Boulder Plateau. Elsewhere in the township sapling growth is exceedingly abundant outside the subalpine areas, lodgepole pine everywhere replacing the burned red fir. Large tracts of the burns have restocked with close-set stands of aspen, which here and there is giving way to lodgepole pine.

Undergrowth.—Abundant throughout, except at subalpine elevations.

Litter.—Abundant almost everywhere. On the burned-over areas the litter is enormous in quantity. The fire ran through exceedingly close-set lodgepole pine stands without consuming the trees, merely killing them, and the dead timber, now falling, forms almost impenetrable masses of woody débris.

Humus.—In the unburned forest, especially in the bottoms of West Boulder Valley, a layer of moss 6 to 8 inches deep forms the humus. In the drier situations this layer is only an inch or two in depth.

Classification of lands in T. 4 S., R. 11 E.

	Acres.
Forested	10,240
Nonforested	12,800
Badly burned	2,400
Logged	1,800
Agricultural	None.
Grazing	4,500
Bare rocks	5,100
Ponds and streams	800

Total stand of timber in T. 4 S., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	10,000,000	14,000,000	15,800,000
White-bark pine	....	3,000,000	3,000,000
Red fir	18,000,000	6,000,000	9,240,000
Subalpine fir	....	3,000,000	3,000,000
Engelmann spruce	12,000,000	5,000,000	7,160,000
Total	40,000,000	31,000,000	38,200,000

Composition of forest in T. 4 S., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	40
White-bark pine	2.2
Red fir	35
Subalpine fir	2
Engelmann spruce	20
Aspen and cottonwood	.8

TOWNSHIP 4 SOUTH, RANGE 12 EAST.

Topography.—The western and central areas of the township consist of high rocky spurs stretching eastward from the so-called West Boulder Plateau. They attain elevations of 10,000 feet and end with steep, bowlder-strewn fronts on the valley of Boulder River, which cuts through the eastern part of the township. The bottoms of this valley, one-fourth mile or less in width, consist of two or three low terraces. The valley is hemmed in on the west and east by steep, cliff-lined, talus-covered slopes rising 2,500 to 3,000 feet before merging with the summit levels of the inclosing ridges.

Mining.—Placer claims and prospects on quartz leads of uncertain value are located along Boulder Valley. None are ore producing, and the placers are not now worked for their mineral contents, but have mostly been turned into hay meadows and pastures.

Minerals.—Gold.

Soil.—Thin and gravelly, consisting almost wholly of detritus derived from hard, siliceous granite rocks, with a slight top-dressing of loamy matter. Much of the levels and terraced slopes in the Boulder Valley are thickly strewn with bowlders.

Agricultural adaptability.—Small tracts of land on the lowest terraces in the Boulder Valley are utilized for agriculture. In the aggregate 1,200 acres are cultivable. The slopes and summits of the ridges and spurs are too steep and rocky, and situated at too high altitudes to be available for farming.

Grazing capacity.—The tracts at present utilized for pasture comprise 4,500 acres, and consist of temporarily deforested fire glades in the Boulder Valley and of alpine and subalpine meadows on the high summits bordering the valley.

Drainage conditions.—A large volume of run-off originates in the township. The district contains no lakes nor tarns, but the high areas in the western and central portions give rise to numerous creeks. The drainage is carried by Boulder River, which here is from 25 to 35 feet wide, with a depth varying from 14 to 25 inches at medium stage of water. The stream along its lower courses in the townships north of the reserve is of great importance in irrigation work.

Snow and rock slides.—Of frequent occurrence along the steep breaks of Boulder Valley.

Towns and settlements.—The district contains no towns. Farmsteads are scattered along Boulder Valley on the agricultural lands. Near the north line of the township, in the valley, is a small collection of houses, or a sort of hamlet, named Contact. Miners' cabins are scattered throughout the mineral-bearing areas.

Forest conditions.—The forest is thinly stocked. At low altitudes it consists of small stands of lodgepole pine and red fir, surrounded by extensive burns, while at higher elevations thin lines of trees and copses of small extent are scattered among the rocky breaks and grassy glades. Most of the timber grows in inaccessible places and has only a fuel value.

Cutting.—The timber in the accessible portions of the Boulder Valley was culled by tie makers in 1882–83. Since then most of the cutting has been to supply the local demand of the farmers in the region. Small quantities have been cut here and there by prospectors and miners. In all, 2,500 acres have been cut over, and 60 per cent of the timber on these tracts removed.

Burns.—The region has been visited by severe and extensive fires, mostly during 1882–83. The immediate valley of Boulder River has suffered most severely, and many of the fires have been clean burning, consuming everything. In the aggregate, 7,600 acres have been burned over.

Reproduction.—The restocking processes throughout the district are slow and deficient. In the subalpine areas young growth is scanty. The burned-over tracts are reforesting tardily, lodgepole pine at low and middle elevations everywhere replacing the former stands of red fir.

Undergrowth.—The brush growth is scanty except here and there on the burned-over tracts, where close growths of *Ceanothus* are occupying the ground and preventing reforestation.

Litter.—In portions of the burned-over ground and in lodgepole-pine stands 75 to 90 years old are large accumulations of dead and fallen pole timber in various stages of decay.

Humus.—None.

Classification of lands in T. 4 S., R. 12 E.

	Acres.
Forested	6,000
Nonforested	17,040
Badly burned	7,600
Logged and culled over	2,500
Agricultural	1,200
Grazing	3,000
Bare rocks and alpine	5,240

Total stand of timber in T. 4 S., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B.M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine		4,000,000	4,000,000
White-bark pine		200,000	200,000
Red fir	2,800,000	2,500,000	3,004,000
Subalpine fir		350,000	350,000
Engelmann spruce	800,000	500,000	644,000
Total	3,600,000	7,550,000	8,198,000

Composition of forest in T. 4 S., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	50
White-bark pine	.5
Red fir	45
Subalpine fir	1.5
Engelmann spruce	3

Township 4 South, Range 13 East.

Topography.—The western and central areas comprise high, subalpine tracts rising to altitudes of 10,000 feet. In the eastern areas the narrow, rocky canyon of the East Boulder cuts through the mountains, which, on the eastern side of the canyon, again rise steeply to subalpine heights.

Mining.—None.

Soil.—Gravelly loam, mostly stony and strewn with bowlders.

Agricultural adaptability.—Small tracts, in all 500 acres, situated in the canyon of the East Boulder are tillable. The remainder of the township is too high and rocky for agriculture.

Grazing capacity.—The township contains no proper grazing lands. Small glades and temporarily deforested burns are used as pasture ground by the few settlers in Boulder Valley.

Drainage conditions.—The high subalpine areas, from which snow is never absent any great length of time, discharge a large amount of water, most of which runs off by way of East Boulder Canyon. The tract as a whole is an important natural reservoir for maintaining the flow in the main Boulder River, the water of which is largely used for irrigation purposes on the agricultural lands adjoining the Yellowstone Valley.

Snow and rock slides.—Frequent in the high areas in the southeast corner of the township.

Towns and settlements.—Six settlers live on the agricultural lands in East Boulder Canyon. Outside this area the township is not inhabited.

Forest conditions.—The lower portions of East Boulder Canyon bear close-set stands of red fir, lodgepole pine, and spruce, one-third of which is sapling growth, representing reforestations after fires which burned a half century ago. The old growth varies from 120 to 175 years of age. The red fir is mostly of the tall, slender type, the spruce of the low, stocky, limby form. The subalpine species are scattered, some as small copses or thin lines, others in compact stands of larger extent. This township at its lower and middle elevations, and particularly in the East Boulder canyons, has been one of the best stocked townships in the reserve, but owing to fires has lost most of its timber during the last twenty or twenty-five years.

Cutting.—The cutting has been confined to the lower portions of Boulder Canyon. Part of the cut has been for local and farm use, part for sawmill purposes. The cut and culled areas aggregate 1,500 acres.

Burns.—Extensive burns have devastated the township, chiefly in the southern and eastern areas, destroying the forest on 5,700 acres.

Reproduction.—Restocking of the recent burns has not yet begun. On the older burns a close-set young growth of lodgepole pine is replacing the former stands of spruce and red fir. In the subalpine stands young growth is moderately abundant, and is sufficient to maintain the present density of the forest. It is chiefly composed of Engelmann spruce.

Undergrowth.—Dense willow and alder brush are abundant in the canyon bottoms and on the lower slopes. In the subalpine stands there is little underbrush.

Litter.—Throughout the burns and in the sapling stands there is a great deal of litter consisting of dead and fallen fire-killed timber in various stages of decay.

Humus.—The humus on northern slopes consists of a thin moss cover, and elsewhere of light layers of pine needles.

Classification of lands in T. 4 S., R. 13 E.

	Acres.
Forested	14,440
Nonforested	8,600
Badly burned	5,700
Logged	1,500
Agricultural	500
Grazing	None.
Bare rocks	2,000
Lakelets, tarns, and streams	400

Total stand of timber in T. 4 S., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	10,000,000	16,000,000	17,800,000
White-bark pine		2,000,000	2,000,000
Red fir	8,000,000	5,000,000	6,440,000
Subalpine fir		4,000,000	4,000,000
Engelmann spruce	6,000,000	2,000,000	3,080,000
Total	24,000,000	29,000,000	33,320,000

Composition of forest in T. 4 S., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	4
Red fir	10
Subalpine fir	10
Engelmann spruce	16

TOWNSHIP 4 SOUTH, RANGE 14 EAST.

Topography.—The western and central areas of the township comprise steep, rough mountains rising to elevations of 10,000 feet. In the eastern areas the slopes gradually spread out and form long and comparatively low ridges and spurs.

Mining.—None.

Soil.—Stony, gravelly, and strewn with bowlders.

Agricultural adaptability.—The region is worthless for agriculture, owing partly to its thin and stony soil, but chiefly to its high altitude.

Grazing capacity.—No portion of the region is a proper grazing tract, but the woodlands in the northeast corner of the township, comprising 2,000 acres, have a grass and sedge cover, and would serve for pasturage purposes.

Drainage conditions.—The run-off is small in volume, and is mostly confined to the western slope, whence it flows into East Boulder River. On the eastern areas of the township most of the water channels are dry runs during the larger portion of the year.

Snow and rock slides.—Infrequent.

Towns and settlements.—None.

Forest conditions.—The forest is of the subalpine type. Along creeks and on northern slopes of ridges where it has not been destroyed by fire it is generally low and scrubby, and consists of scattered patches and isolated stands. It has only a fuel value. Much of it forms the timber-line fringe of arborescent growth, and is depressed to the stature of shrubs.

Woodlands.—The timber growth in the northeast corner of the township consists of scattered trees and small copses, chiefly limber pine, with small proportions of red fir, and constitutes woodlands. The tract contains 2,000 acres, and the timber on the same has only a fuel value.

Cutting.—None.

Burns.—Extensive burns occur throughout the forested areas. They date back seven or eight years, and have destroyed the timber on over 14,000 acres.

Reproduction.—Scanty throughout and on the burned areas mostly lacking. The woodlands have scarcely any young growth. Lodgepole pine forms the bulk of the restockage at the higher elevations, red fir at lower altitudes.

Undergrowth.—Very light.

Litter.—The burned-over areas are encumbered with large quantities of partly consumed woody débris. In the woodlands litter is lacking.

Humus.—None.

Classification of lands in T. 4 S., R. 14 E.

	Acres.
Forested	3,900
Wooded	2,000
Nontimbered	17,140
Badly burned	14,530
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and alpine	2,610

Total stand of timber (pole and fuel) in T. 4 S., R. 14 E.

	Cubic feet.
Limber pine	1,000,000
Lodgepole pine	2,000,000
White-bark pine	500,000
Red fir	500,000
Subalpine fir	850,000
Engelmann spruce	600,000
Total	5,450,000

Composition of forest in T. 4 S., R. 14 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	75
White-bark pine	4
Subalpine fir	10
Engelmann spruce	11

Composition of the woodland growth in T. 4 S., R. 14 E.

	Per cent.
Limber pine	80
Red fir	20

TOWNSHIP 4 SOUTH, RANGE 15 EAST.

Topography.—The relief of the region is made up of numerous low ridges and combs, separated by comparatively broad and shallow canyons; the whole forms a sort of rolling plateau region constituting foothill country on the western slopes of the East Boulder-Stillwater divide.

Mining.—None.

Soil.—Gravelly loam is found in the southwestern areas. In the remainder of the township the soil is clayey and gumbo-like.

Agricultural adaptability.—The rolling character of the region and the impossibility of irrigation in the district preclude agricultural operations.

Grazing capacity.—Practically the entire township is a grazing area. In the northwest corner of the township fire has destroyed the forest cover on a small tract and made it temporarily available for grazing. With the exception of this area all of the woodlands and the nontimbered tracts, separating the different stands of arborescent growth, are covered with a thick and close sward of bunch grasses, not yet very closely pastured.

Drainage conditions.—The outflow from the township is insignificant in volume. Most of the creeks and canyons are mere dry runs. The lack of water is probably the reason for the small amount of pasturing to which the tract has been subjected.

Snow and rock slides.—None.

Towns and settlements.—None.

Forest conditions.—The township contains no forest.

Woodlands.—The woodlands comprise 60 per cent of the tract. The timber occurs as small copses, thin lines, and single trees scattered over the entire tract. The growth is composed of limber pine, red fir, and yellow pine. The pines are mostly old growths, while of the red fir 50 per cent are sapling stands.

Cutting.—None.

Burns.—In the northwest corner 1,500 acres of land formerly forest covered have been burned over within the past six or eight years.

Reproduction.—Red fir is reproducing freely, and in many places along the west line of the township this species is encroaching on the woodland area. The reproduction of the limber and yellow pine is slow and deficient.

Undergrowth.—Very sparse; in most places lacking.

Litter.—None.

Humus.—None.

Classification of lands in T. 4 S., R. 15 E.

	Acres.
Forested	None.
Wooded	13,000
Nontimbered	10,040
Badly burned	1,500
Logged	None.
Agricultural	None.
Grazing	8,540

Total stand of timber in T. 4 S., R. 15 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		850,000	850,000
Yellow pine	100,000	50,000	68,000
Red fir	400,000	900,000	972,000
Total	500,000	1,800,000	1,890,000

Composition of forest in T. 4 S., R. 15 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	37
Yellow pine	2
Red fir	60
Aspen and cottonwood	1

TOWNSHIP 4 SOUTH, RANGE 16 EAST.

Topography.—The township consists of a rolling table-land varying in elevation from 5,500 to 6,000 feet. It is cut and furrowed by numerous shallow canyons, ravines, and gullies, and in its eastern portion by the valley of Stillwater River.

Mining.—None.

Soil.—Clayey loam. Sandy, gravelly, and bowlder-strewn tracts are of common occurrence in the valleys.

Agricultural adaptability.—The valleys are agricultural where not too stony. In some localities the uplands are tillable without irrigation, but in general the higher ground can not be cultivated successfully without irrigation.

Grazing capacity.—The entire township, outside the tracts actually in cultivation, is essentially a grazing area.

Drainage conditions.—Very little drainage originates in the township. Water for irrigation is obtained from the streams, chiefly from Stillwater River, that head in the mountain regions to the south.

Snow and rock slides.—None.

Towns and settlements.—Farmsteads are scattered throughout the township on the agricultural lands. There are no villages or towns.

Forest conditions.—The township contains no forested areas.

Woodlands.—Scattered trees and small copses of aspen, red fir, and limber pine occur over most of the township. The growth is too thin to classify the tract even as woodland, in the strict sense of the word.

Cutting.—The timber has been culled over throughout for farm uses.

Burns.—None.

Reproduction.—There is a moderate amount of young growth in the southern portions of the township, where stands of red fir are springing up on many of the northern slopes and show a marked tendency to spread into the adjoining grassy, nontimbered areas. Most of the district is capable of supporting moderately well-stocked stands of red fir and limber pine. Its present grassy, lightly timbered condition is wholly due to repeated fires during centuries of Indian occupancy, with the consequent suppression of seedling growth.

Undergrowth.—None.

Litter.—None.

Humus.—None.

Classification of lands in T. 4 S., R. 16 E.

	Acres.
Woodland grazing	20,500
Agricultural	2,540

Total stand of timber (pole and fuel) in T. 4 S., R. 16 E.

	Cubic feet.
Limber pine, yellow pine, red fir	900,000

Composition of the woodland stands in T. 4 S., R. 16 E., including trees of all [illegible] 3 inches and upward.

Limber pine	[illegible]
Yellow pine	20
Red fir	50

TOWNSHIP 4 SOUTH, RANGE 17 EAST.

Topography.—This township consists of rolling plains intersected by small draws and creek bottoms and, in the western areas, cut by the comparatively level and shallow valley of Stillwater River. Bluffs and steep escarpments of rock border most of the larger creek valleys.

Mining.—None.

Soil.—Sandy and gravelly loam, here and there bowlder strewn; the loam is deep and rich.

Agricultural adaptability.—The lands are agricultural wherever irrigation is possible.

Grazing capacity.—The tract is grass covered throughout where not cultivated. It has been badly overgrazed in all localities.

Drainage conditions.—Small springs occur here and there. Very little drainage originates on the tract. Most of the runs and creeks heading in the township are dry during the greater part of the year.

Towns and settlements.—There are no towns in the region; farmsteads occur wherever agriculture is possible, particularly in Stillwater Valley.

Forest and woodland conditions.—The township contains no forested areas. The woodlands consist of scattered limber pine and occasional yellow pines, small aspen groves and cottonwood along the creek bottoms and around springy places—practically merely small wood lots.

TOWNSHIP 5 SOUTH, RANGE 10 EAST.

Topography.—This township comprises a portion of the main Absaroka range situated between the drainage of West Boulder River and Yellowstone River on the west. It is a rough bed of mountains, chiefly situated above the 9,000-foot contour, a few of the peaks rising to elevations of 11,200 feet. It is deeply and boldly sculptured, and bristles with jagged summits, overhangs, and pinnacles.

Mining.—None.

Soil.—Thin, stony, and bowlder strewn. Much of the higher areas are entirely devoid of soil.

Agricultural adaptibility.—The altitude of the township prevents agriculture.

Grazing capacity.—In all places in the alpine and higher subalpine areas where a soil cover exists the ground is covered with a grassy or sedgy turf. All of these tracts are inaccessible for stock.

Drainage conditions.—The volume of water flowing from the township is large. Part of it drains into West Boulder River and part into the Yellowstone on the west through various small creeks, the waters of which are used for irrigation purposes in Yellowstone Valley.

Snow and rock slides.—Favored by the steep slopes, precipices, and unstable conditions of the talus slopes, snowslides and rock slips are of frequent occurrence.

Towns and settlements.—The township is uninhabited.

Forest conditions.—The high elevation of the region is prohibitive to an extensive development of the forest. Most of the tract is situated above timber line. The forest is largely of the pure subalpine type, scattered thinly over the slopes, growing in small copses in the hollows among outjutting ledges, and forming more or less continuous stands in the bottoms of the larger canyons. The heaviest stands of timber in the township occur in the main canyons of West Boulder River and on the slopes facing Yellowstone Valley. They are composed of lodgepole pine and Engelmann spruce, and in the southwest corner of the township are chiefly made up of sapling stands. Small tracts fronting on Yellowstone Valley are accessible for logging operations; most parts can not be reached.

Cutting.—None.

Burns.—In the aggregate, 450 acres in the western areas.

Reproduction.—Scanty in the subalpine forest; abundant on the western areas, where the lodgepole pine predominates in all the young growth.

Undergrowth.—Willows, alders, and mountain ash along the streams. The subalpine forest has little brush growth.

Litter.—Abundant in the western areas and consisting of dead and down timber.

Humus.—Thin cover of moss on northern slopes.

Classification of lands in T. 5 S., R. 10 E.

	Acres.
Forested	8,000
Nonforested	15,040
Badly burned	450
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and alpine	14,590

Total stand of timber in T. 5 S., R. 10 E.

Species.	Mill timber.	[illegible]	[illegible]
	Feet B. M.		
Lodgepole pine	3,000,000	[illegible]	[illegible]
White-bark pine			[illegible]
White pine	50,000	[illegible]	[illegible]
Red fir	1,200,000	400,000	[illegible]
Subalpine fir		900,000	[illegible]
Engelmann spruce	2,500,000	2,000,000	[illegible]
Total	6,750,000	7,800,000	9,[illegible]

Composition of forest in T. 5 S., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	4
White pine	Scattered trees.
Red fir	8
Subalpine fir	15
Engelmann spruce	13

Township 5 South, Range 11 East.

Topography.—The township consists of an extremely rough mass of mountains rising to altitudes of nearly 11,000 feet, bristling with peaks, pinnacles, crags, and overhang, cut by rocky, cliff-bound canyons, the bottoms of which are littered with masses of gravel and bowlders.

Mining.—None.

Soil.—The soil is thin and barren and is chiefly made up of sand and gravel with a thin cover of loam. Large tracts of the alpine and subalpine areas are entirely devoid of soil cover.

Agricultural adaptability.—There is no tillable land in the township; the entire district is nonagricultural.

Grazing capacity.—A limited amount of pasturage is furnished by small glades along the bottoms of the different canyons, and by high alpine and subalpine meadows on the summits of the ridges. However, most of the high-lying glades and meadows are practically inaccessible for stock and can not be utilized for range purposes.

Drainage conditions.—The run-off from the township is large, the discharge being chiefly by way of West Boulder River. Springs, small creeks, and alpine rivulets abound, and the higher peaks retain large banks of snow on their northern slopes throughout the summer.

Snow and rock slides.—These are frequent in all parts of the township. Few of the slopes have as yet acquired stability; the crests of the ridges are deeply fissured, broken, and crumbling, and with the vast amount of overhang existing in many places rockslides and landslips are of common occurrence.

Towns and settlements.—The region is uninhabited.

Forest conditions.—Most of the forest is of subalpine type and consists of old-growth stands. Up to timber line the ridges bear scattered copses and lightly stocked stands of lodgepole pine, spruce, subalpine fir, and white-bark pine, all low and limby and, near the timber line, depressed to the stature of shrubs. The heaviest stands occur in the valley of the West Boulder and are composed of lodgepole pine and spruce, with red fir on the drier and warmer exposures. The timber in West Boulder Valley is accessible for logging, although with some difficulty owing to the bowlder-strewn condition of the valley bottom. The timber on the slopes is inaccessible. West Boulder River can probably be utilized for driving purposes early in the season.

Cutting.—None.

Burns.—Scattered patches of forest here and there in the valley of West Boulder have been damaged by fires of recent date.

Reproduction.—At the lower elevations there is enough young growth to maintain the present average density of the stands. In the higher subalpine areas the reproductive capacity of the forest is low, and the trees show little tendency toward spreading into the various grassy, nontimbered glades that break the continuity of the stands.

Undergrowth.—The bottoms of the West Boulder and its larger laterals bear thick and tangled masses of willows, alders, etc. There is little brush growth in the stands on the ridges.

Litter.—The forest in West Boulder Valley is littered with large quantities of dead and fallen timber. Elsewhere in the township the litter is light.

Humus.—The forest floor on the western slopes of West Boulder Valley is covered with a 3 to 4 inch layer of moss and pine needles. In the subalpine stands humus is very light or mostly lacking.

Classification of lands in T. 5 S., R. 11 E.

	Acres.
Forested	7,040
Nonforested	16,000
Badly burned	200
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and alpine	15,600
Streams and tarns	200

Total stand of timber in T. 5 S., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	[illegible]	[illegible]
Lodgepole pine	5,800,000	7,000,000	8,044,[illegible]
White-bark pine		[illegible],000	[illegible]
Red fir	4,000,000	[illegible]000,000	[illegible]
Subalpine fir		[illegible]000,000	2,[illegible]
Engelmann spruce	4,000,000	[illegible],800,000	8,[illegible],000
Total	13,800,000	[illegible]4,800,000	17,284,000

Composition of forest in T. 5 S., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	3
Red fir	25
Subalpine fir	7
Engelmann spruce	5

TOWNSHIP 5 SOUTH, RANGE 12 EAST.

Topography.—The western and central areas comprise high, rough mountain summits, and spurs varying in elevation from 9,000 to 11,000 feet. The spurs are long lobes or eastward extensions from the so-called West Boulder Plateau in the township adjoining on the west. They are gashed in their fronts by extremely precipitous, narrow, rocky canyons, and where they terminate in the valley of Boulder River present enormous cliffs and rough, boulder-strewn slopes. The eastern part of the township contains a portion of the valley of Boulder River, a narrow, cliff-bound trough, its eastern declivities consisting of steep talus slopes, its bottoms terraced with morainic gravel and bowlder débris.

Mining.—Here and there in the valley and lateral canyons of Boulder River small placers were formerly worked. There are prospects on quartz leads in various localities throughout the township. No active mining is carried on.

Minerals.—Gold and copper.

Soil.—Thin, gravelly, and rocky.

Agricultural adaptability.—Small tracts in Boulder Valley, in the aggregate 300 acres, largely patented placer ground, are tillable and are under cultivation. Outside this valley none of the lands are tillable, by reason of their rocky character and altitude.

Grazing capacity.—The grazing lands in the township consist of small glades along Boulder River, fire glades on the rocky slopes fronting this valley, and alpine sedge and grass-covered summits of the high spurs in the western areas, in the aggregate 8,000 acres. Most of the high areas are accessible only for sheep.

Drainage conditions.—Large volumes of water originate in the high alpine and subalpine regions in the western and central areas and discharge into Boulder River. The eastern areas of the township shed little water.

Snow and rock slide.—Frequent in all of the western and central areas.

Towns and settlements.—No towns; five or six farmsteads in Boulder Valley.

Forest conditions.—The western and much of the central areas are situated above timber line and carry no forest. In the Boulder Valley the timber is mostly scattered over the rocky western slopes; small, compact bodies of red fir, mixed with lodgepole pine, occur here and there where the lateral canyons enter the valley. In the bottom of the valley the forest was badly burned in 1882–83, and the present stands consist largely of sapling lodgepole pine, which has replaced the former growth of red fir. In the extreme eastern portion of the township is a burned-over area with occasional patches of very young sapling growth of lodgepole pine, and irregular, thin lines of red fir and lodgepole pine, which mark the remains of the former old growth. Most of the timber is inaccessible for logging operations. It is low, limby, and scrubby, but is valuable for its effect in imparting stability to the slopes and their talus accumulations.

Cutting.—The tie makers cutting for the Northern Pacific Railroad in 1882–83 culled 75 per cent of the accessible timber in Boulder Valley.

Burns.—Fires dating from 1882–83 have run over most of the forested areas, destroying the timber on 8,900 acres.

Reproduction.—In Boulder Valley lodgepole-pine stands are slowly reforesting the burned-over areas. On the southern slopes of the valley reproduction is generally scanty and deficient, most of the burns being bare of young growth. The red-fir stands on the western slope are gradually gaining in density, while along the subalpine areas the young growth is thin or altogether wanting.

Undergrowth.—Moderate throughout, largely composed of *Ceanothus velutinus.*

Litter.—Abundant throughout the burned areas, and consisting of dead and fallen timber partly consumed by fire or merely fire killed and thrown down by wind. There are only small quantities of litter in the green stands.

Humus.—None.

Classification of lands in T. 5 S., R. 12 E.

	Acres.
Forested	3,440
Nonforested	19,600
Badly burned	8,900
Logged	1,800
Agricultural	300
Grazing	8,000
Bare rocks and alpine	2,400

Total stand of timber in T. 5 S., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	[illegible]	[illegible]
Lodgepole pine		1,000,000	1,000,000
White-bark pine		[illegible]00,000	[illegible]
Red fir	2,900,000	[illegible]000,000	[illegible]
Subalpine fir		400,000	400,000
Engelmann spruce	600,000	500,000	[illegible]
Total	3,500,000	[illegible], 200,000	[illegible]

Composition of forest in T. 5 S., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	30
White-bark pine	2
Red fir	60
Subalpine fir	3
Engelmann spruce	5

TOWNSHIP 5 SOUTH, RANGE 13 EAST.

Topography.—An elevated plateau-like area known as East Boulder Plateau occupies the central areas of the township. Its altitude varies from 10,000 to 11,000 feet. Its summit is intersected by numerous ridges and depressions, and by the shallow canyon heads of great gorges that cut into its sides. In the eastern and western portions of the township the plateau breaks off in great cliffs and escarpments to the canyons of Boulder and East Boulder rivers, rising again on the east bank of the latter stream in ridges 10,000 feet in altitude.

Mining.—None.

Soil.—Thin, gravelly loam underlaid and mixed with vast masses of bowlders.

Agricultural adaptability.—The township, owing to its great altitude, contains no arable land.

Grazing capacity.—The summit of East Boulder Plateau, where not too rocky, is covered with a sward of alpine sedges and grasses. The tract is extremely difficult of access, but has been utilized for sheep pasture in former years. Outside of the plateau the township has no grazing areas.

Drainage conditions.—The run-off is large. The tract contains no lakes, but springs and creeks are numerous and furnish large additions to the volume of water in East Boulder and Boulder rivers.

Snow and rock slides.—Avalanches and landslips are of frequent occurrence along the edges and steep slopes of the plateau.

Towns and settlements.—The township is not inhabited.

Forest conditions.—The forest is confined to the eastern areas of the township in East Boulder Valley. It consists of lodgepole pine and Engelmann spruce in moderately close-set stands, largely old growths. At the brinks of the plateau and following the canyon heads into the more level tracts of the table-land are thin scattered stands of subalpine forest, mostly composed of spruce and white-bark pine.

Cutting.—None.

Burns.—Scattered tracts in East Boulder Valley.

Reproduction.—Moderate and composed of the same species and in nearly the same proportions as prevail in the old stands. In the high subalpine forest young growth is scanty.

Undergrowth.—Sparse.

Litter.—In the bottoms of the East Boulder, litter is abundant. In the subalpine forest it is light or altogether lacking.

Humus.—Light.

Classification of lands in T. 5 S., R. 13 E.

	Acres.
Forested	10,000
Nonforested	13,040
Badly burned	3,200
Logged	None.
Agricultural	None.
Grazing	5,800
Bare rocks and alpine	4,040

Total stand of timber in T. 5 S., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	8,000,000	10,000,000	11,440,000
White-bark pine		900,000	900,000
Subalpine fir		4,000,000	4,000,000
Engelmann spruce	15,000,000	6,000,000	8,700,000
Total	23,000,000	20,900,000	25,040,000

Composition of forest in T. 5 S., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	40
White-bark pine	6
Subalpine fir	10
Engelmann spruce	44

TOWNSHIP 5 SOUTH, RANGE 14 EAST.

Topography.—The township is situated on the summits and slopes of the divide between East Boulder River and the West Fork of the Stillwater drainage. It comprises high, rocky ridges, the central summits attaining altitudes of nearly 10,000 feet. It is cut into by numerous rocky, precipitous canyons, and intersected by the West Fork of the Stillwater from southwest to northeast.

Mining.—None.

Soil.—Gravelly and stony.

Agricultural adaptability.—The tract is essentially a mass of mountains and contains no arable land.

Grazing capacity.—None.

Drainage conditions.—Owing to the altitude and position of the township it receives large quantities of snow, and the run-off is large. There are no lakes nor tarns, but numerous springs and creeks. The tract supplies important feeders to East Boulder River and to the Stillwater drainage.

Snow and rock slides.—Infrequent.

Towns and settlements.—None.

Forest conditions.—The forest of the township consists chiefly of lodgepole pine in the sapling stage, mixed, at high elevations, with stocky white-bark pine, Engelmann spruce, and subalpine fir. With the possible exception of a small tract in the southeast corner in the West Fork of Stillwater Valley, it is practically inaccessible to logging operations.

Cutting.—None.

Burns.—Very extensive burns dot the township in all directions, but more particularly in the northern areas. The fires date back seven or eight years, and have made a clean sweep of the timber wherever they burned.

Reproduction.—The young growth is insufficient to fully stock the forest to its ultimate capacity. The burned-over areas are not freely restocking. Lodgepole pine is the chief species in the reforestations.

Undergrowth.—Scanty.

Litter.—There is a large amount of litter, both in the green stands and on the burned-over areas. Most of it is composed of fire-killed and unconsumed timber.

Humus.—None.

Classification of lands in T. 5 S., R. 14 E.

	Acres.
Forested	11, 240
Nonforested	11, 800
Badly burned	9, 000
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks	2, 800

Total stand of timber in T. 5 S., R. 14 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	5, 000, 000	8, 800, 000	9, 700, 000
White-bark pine		1, 000, 000	1, 000, 000
Subalpine fir		4, 800, 000	4, 800, 000
Engelmann spruce	3, 500, 000	2, 000, 000	2, 630, 000
Total	8, 500, 000	16, 600, 000	18, 130, 000

Composition of forest in T. 5 S., R. 14 E., including trees of all species having basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	70
White-bark pine	5
Subalpine fir	10
Engelmann spruce	15

Township 5 South, Range 15 East.

Topography.—The northern portions of the township consist of a rolling table-land, with numerous small canyons, ravines, and gullies intersecting it in various directions. Its altitude varies from 5,000 to 5,500 feet. The central and the southern areas comprise rough, steep mountains which reach altitudes of 9,000 feet, and through which Stillwater River, West Fork, and Lime Creek have cut narrow, terraced canyons and valleys.

Mining.—There are numerous mineral prospects throughout the central portions of the township.

Minerals.—Silver, gold, copper, and lead.

Soil.—The soil is gravelly loam, generally shallow and bowlder strewn. The lowest terraces of Stillwater Valley and of Lime Creek are covered with deeper loam, resting on barren gravel deposits. The middle and upper terraces of Stillwater Valley are made up of coarse and heavy gravel and bowlder drift.

Agricultural adaptability.—Where the soil is not too stony and irrigation is possible the valley terraces are under cultivation. The mountain slopes and the table-land in the northern portion of the district are not arable.

Grazing capacity.—The northern and central areas contain a large acreage of nontimbered slopes and bowlder terraces suitable for grazing purposes, and so used. Most of this land is more or less completely inclosed with fences and therefore is not overgrazed.

Drainage conditions.—The outflow originating in the township is of small volume. A large amount originating elsewhere flows through it and is extensively drawn on for irrigation purposes.

Snow and rock slides.—Infrequent.

Towns and settlements.—The farming lands are settled and permanently occupied. At the junction of Stillwater River with West Fork is the small village of Nye, composed of half a dozen houses.

Forest conditions.—Most of the forest is composed of low subalpine species. Nearly one-fourth consists of sapling lodgepole pine. The forest is chiefly confined to the western areas of the township, and its most valuable portions are comparatively easy of access.

Woodlands.—The woodlands are limited to the northern portion and comprise 1,500 acres. The stands are thin and scattering, mostly mere lines, small groups, or isolated trees, and consist of limber pine, red fir, and a few yellow pines.

Cutting.—More than 1,500 acres have been cut and culled, mostly in the southwest quarter, where a sawmill has been in operation for a number of years. The cut amounts to 50 per cent of the original stand.

Burns.—Extensive and mostly clean-burning fires have destroyed the forest on 8,000 acres. The fires date back seven or eight years.

Reproduction.—Restocking of the burned-over areas has, in most localities, not yet fairly begun. The coming growth will be lodgepole pine. In the unburned timber reproduction is sufficient to maintain the present stands. In the woodlands young growth is gradually extending into the grassy areas and will, in course of time, cover them with stands of forest.

Undergrowth.—Scanty throughout; none in the woodlands.

Litter.—In some of the burns the fire-killed timber is now beginning to fall and the litter is rapidly increasing. In the green timber there is only a moderate quantity.

Humus.—None.

Classification of lands in T. 5 S., R. 15 E.

	Acres.
Forested	5,500
Wooded	1,500
Nontimbered	16,040
Badly burned	8,000
Logged and culled	1,500
Agricultural	2,000
Grazing	5,200
Bare rocks	840

Total stand of timber in T. 5 S., R. 15 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		250,000	250,000
Lodgepole pine	3,500,000	5,500,000	6,130,000
White-bark pine		300,000	300,000
Red fir	300,000	200,000	254,000
Subalpine fir		450,000	450,000
Engelmann spruce	550,000	2,000,000	2,099,000
Total	4,350,000	8,700,000	9,483,000

Grazing capacity.—All of the region not under cultivation has a grazing value. Most of it has been badly overgrazed in the past, and its present pasturage value is low.

Drainage conditions.—The run-off which originates on the tract is insignificant in volume. West Rosebud and Fishtail creeks flow across portions of the township. These streams and a number of smaller creeks are utilized for irrigation purposes.

Towns and settlements.—Farmsteads are scattered throughout the township on the agricultural lands, mostly in the western areas. There are no towns.

Forest and woodland conditions.—The township contains no forested areas. The woodlands are mostly confined to the western areas and are found along creeks and here and there on the northern slopes of the ridges. Limber pine, yellow pine, aspen, cottonwood, and willow make up the growth, which is thin and scattering.

Cutting.—All of the woodland area has been cut and culled over for local farm uses. The cutting has extended over a period of twenty to twenty-five years or longer, and, as nearly as now can be determined, amounts to 50 per cent of the original stand.

Burns.—None.

Reproduction.—Aspen and cottonwood abundant. Seedling and sapling growths of coniferous species are nearly lacking.

Classification of lands in T. 5 S., R. 17 E.

	Acres.
Forested	None.
Wooded	3,200
Nontimbered	19,840
Badly burned	None.
Logged and culled	3,200
Agricultural grazing	19,840

Total stand of timber (pole and fuel) in T. 5 S., R. 17 E.

	Cubic feet.
Limber pine	1,000,000
Yellow pine	380,000
Aspen and cottonwood	400,000
Total	[illegible],780,000

Composition of the woodland arborescent growth in T. 5 S., R. 17 E., including trees of all species [illegible] diameters of 3 inches and upward.

	Per cent.
Limber pine	8
Yellow pine	1
Aspen and cottonwood	91

Township 6 South, Range 10 East.

Topography.—The township lies almost entirely in the Mill Creek drainage. The northern areas comprise high ridges, with elevations up to 10,000 feet, cutting off the Mill Creek drainage from the tracts which slope into Elbow Creek Basin. The remainder of the township is composed of the wide canyons of North, Middle, and Mill creeks, and of the divides separating the two streams.

Mining.—Portions of the lower areas of Mill Creek Basin are mineral bearing and contain scattered prospect holes. No active mining is carried on.

Minerals.—Said to be gold and copper.

Soil.—Usually thin and of no great fertility. The surface is covered with a loamy mixture.

Agricultural adaptability.—The township contains no tillable land, being too stony and mountainous for agriculture.

Grazing capacity.—The grazing areas consist wholly of small glades along Mill Creek forks, not properly grazing lands.

Drainage conditions.—The township contains the principal waterheads of the Mill Creek drainage, and the outflow is large and continuous. The water is used in the Yellowstone Valley to some extent for irrigation.

Snow and rock slides.—Most of the slopes in the basin have acquired a certain degree of stability, and slides either of snow or rock are not frequent.

Towns and settlements.—None.

Forest conditions.—The Mill Creek basins are well stocked with forest, chiefly lodgepole pine of middle age or large sapling stands. On the southern slopes along the main canyons the stands are rather open and scattered, with red fir as the leading species in their composition. At the highest altitudes the growth is largely composed of spruce, with young sapling stands of lodgepole pine marking burns of recent years. As a rule, most of the growth is too small for mill timber, and is difficult of access owing to the narrow and rocky character of the main canyon of Mill Creek in the township adjoining on the west.

Cutting.—None.

Burns.—None.

Reproduction.—Young growth is abundant in most places. As a rule the lodgepole-pine stands and those chiefly composed of spruce are stocked so closely that further additions to the density of the stands are impossible.

Undergrowth.—Sparse.

Litter.—Litter, composed of timber killed by overcrowding, is abundant in all the closely stocked stands. In the subalpine stands there is a scarcity of such material, and the forest is clean and open.

Humus.—In the canyons and on the northern slopes a thin moss cover on the forest floor constitutes the humus. On the southern slopes this cover is lacking.

Classification of lands in T. 6 S., R. 10 E.

	Acres.
Forested	16,540
Nonforested	6,500
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and alpine	6,500

Total stand of timber in T. 6 S., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	30,000,000	35,000,000	40,400,000
White-bark pine		2,000,000	2,000,000
Red fir	6,000,000	5,200,000	6,280,000
Subalpine fir		5,500,000	5,500,000
Engelmann spruce	10,800,000	6,000,000	7,944,000
Total	46,800,000	53,700,000	62,124,000

Composition of forest in T. 6 S., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	5
Red fir	7
Subalpine fir	10
Engelmann spruce	18

TOWNSHIP 6 SOUTH, RANGE 11 EAST.

Topography.—The central areas of the township consist of a section of the main range of the Absaroka Mountains, forming the divide between Mill Creek and Boulder River basins. The ridges attain altitudes of 11,000 feet, and abound with peaked and craggy crests. The eastern area comprises bowlder-littered canyons, opening into the main valley of Boulder River, and separated by rough-crested, narrow, and precipitous ridges. The western area is of similar character, the canyons forming in part the northern and central water heads of the Mill Creek drainage.

Logging.—None.

Soil.—The soil is thin and rocky. In the forested areas it is enriched by a covering of humus and mold. Most of the tract is thickly strewn with bowlders.

Agricultural adaptability.—None of the lands are tillable. They are too stony and are situated at too high altitudes to be available for agriculture.

Grazing capacity.—The tracts which lie above timber line have a small grazing value. They are inaccessible except to sheep.

Drainage conditions.—The tract sheds a large volume of water, owing to its extensive areas of alpine and subalpine country. Springs, marshy tracts, and rivulets are numerous throughout.

Snow and rock slides.—In the central areas avalanches of snow and rock are of frequent occurrence. In other parts they are uncommon, or are altogether absent.

Towns and settlements.—The township is not inhabited.

Forest conditions.—The central areas, lying mostly above timber line, contain no forest. In the eastern areas stands of the subalpine type, well stocked, form most of the timber on the slopes, while lodgepole pine, 100 to 175 years old, mixed with a small proportion of spruce and subalpine fir, cover the bottoms of canyons where not too rocky for timber growth. In the western areas the stands are wholly of the subalpine type, spruce being the leading species.

Cutting.—None of the tract has been cut over.

Burns.—None.

Reproduction.—Scanty in the forest of the pure subalpine type. Young growth in the lodgepole pine stands at the lower elevations is of moderate volume, sufficient to maintain a full stocking of the forest. Most of the young growth consists of spruce; the lodgepole pine, which represents reforestation after ancient fires, is evidently giving way to that species.

Undergrowth.—Huckleberry bushes and honeysuckle form most of the brush growth at lower altitudes. In the subalpine stands underbrush is scanty.

Litter.—The lodgepole pine stands are littered with large quantities of dead and fallen timber, killed by crowding. The subalpine stands contain little dead timber.

Humus.—A thin layer of moss and pine needles forms the humus in the lodgepole-pine forest. The subalpine stands have no humus cover.

Classification of lands in T. 6 S., R. 11 E.

	Acres.
Forested	10,000
Nonforested	13,040
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	8,000
Bare rocks	5,040

Total stand of timber in T. 6 S., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	20,000,000	15,000,000	18,600,000
White-bark pine		1,000,000	1,000,000
Subalpine fir		3,000,000	3,000,000
Engelmann spruce	8,500,000	5,000,000	6,530,000
Total	28,500,000	24,000,000	29,130,000

Composition of forest in T. 6 S., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	80
White-bark pine	2
Subalpine fir	6
Engelmann spruce	12

Township 6 South, Range 12 East.

Topography.—The eastern half of the township consists of a barren, rocky mass of mountains attaining elevations of 11,500 feet; the western half comprises long spurs projecting westward from the main range of the Absaroka Mountains. Between the spurs lie deep canyons littered with glacial gravel and bowlder drift. Through the center of the tract runs Boulder River in a deep, rocky canyon.

Mining.—Here and there in the valley of Boulder River are placer locations. None are worked at present.

Soil.—Gravelly loam, with the surface littered with bowlders.

Agricultural adaptability.—None of the lands are arable.

Grazing capacity.—The grazing areas are limited to small glades and wet meadows along Boulder River and to summits of the ridges in the east half of the township. They are mostly above timber line and are not easily accessible.

Drainage conditions.—The outflow from the township is large and supplies one-half or more of the volume of water in Boulder River at this point.

Towns and settlements.—Near the south end of the township, in Boulder Valley, is a sort of summer resort—Hicks Park, by name—occupying a small glade on the east side of the river. There is no other settlement in the township.

Snow and rock slides.—Avalanches are common along the steep slopes which border Boulder Valley.

Forest conditions.—Boulder Valley and the canyons entering from the east are, as a rule, lightly forested. The valleys on the west side of the Boulder carry close-set stands of forest. Lodgepole pine and Engelmann spruce form the bulk of the stands. All ages between 50 and 200 years are represented. At the higher elevations subalpine fir and spruce constitute the forest. On the rocky slopes of Boulder Canyon red fir, mostly of short, limby growth, is abundant.

Cutting.—Tie cutters of the Northern Pacific Railroad cut and culled 50 per cent of the timber in the valley in 1882–83, since which time miners have cut an additional 10 or 15 per cent.

Burns.—The eastern portion of the valley has experienced severe and extensive burns in the last twenty years. The western has very nearly escaped.

Reproduction.—Restocking of the burned-over areas is as yet slow and deficient. Most of the forest in the bottoms of the canyons and on the lowest slopes outside of Boulder Valley is composed of fully stocked stands, and the young growth in these localities is scanty.

Undergrowth.—The growth is light and consists chiefly of huckleberry and *Ceanothus.*

Litter.—There is a very large amount of dead and fallen timber throughout the forest—partly unconsumed débris from former fires, partly trees killed by crowding.

Humus.—A thin layer of moss and decaying pine needles covers the forest floor in most of the older stands, especially in the canyons on the west side of Boulder River. In other localities humus is lacking.

Classification of lands in T. 6 S., R. 12 E.

	Acres
Forested	12,540
Nonforested	10,500
Badly burned	3,000
Logged	1,500
Agricultural	None.
Grazing	2,500
Bare rocks	5,000

Total stand of timber in T. 6 S., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	16,000,000	15,000,000	17,880,000
White-bark pine		2,000,000	2,000,000
Red fir	6,000,000	8,000,000	9,080,000
Subalpine fir		5,000,000	5,000,000
Engelmann spruce	10,000,000	5,000,000	6,800,000
Total	32,000,000	35,000,000	40,760,000

Composition of forest in T. 6 S., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	2
Red fir	15
Subalpine fir	8
Engelmann spruce	15

TOWNSHIP 6 SOUTH, RANGE 13 EAST.

Topography.—The township comprises alpine and subalpine areas, mostly above the 10,000-foot contour. It is rocky and barren throughout, cut by numerous creeks and canyons and dotted with lakelets and tarns.

Mining.—None.

Soil.—Gravelly, stony, and the surface excessively rocky and bowlder strewn. Much of the tract, especially in the central areas and along the west line, has no soil cover.

Agricultural adaptability.—The township contains no tillable land.

Grazing capacity.—All of the alpine and subalpine areas are covered with grass and sedge wherever a soil cover exists, and are capable of furnishing a small amount of pasturage. The tract is, however, practically inaccessible to any kind of stock except sheep.

Drainage conditions.—Lakelets, tarns, and marshy areas, with which the tract is liberally supplied, act as natural reservoirs and regulate the flow of Boulder and East Boulder rivers, the streams that carry most of the outflow from the township.

Snow and rock slides.—Common in the central areas along the canyon of East Boulder River.

Towns and settlements.—None.

Forest conditions.—Most of the tract is situated above timber line and therefore carries no arborescent growth. Small areas of forest are situated in the bottoms and on the lower slopes of East Boulder Canyon and in ravines along the west line of the township. The trees are strictly a high subalpine type, of no value except for fuel, and are practically inaccessible from the outside.

Cutting.—None.

Burns.—Along the west line of the township 600 acres have been burned over in recent years and the timber totally destroyed.

Reproduction.—Reproduction is deficient throughout the township and is scarcely heavy enough to maintain the present density of stands. There is no restockage in the burns.

Undergrowth.—Light.

Litter.—In the burned-over areas there is a small amount of unburned woody débris of the former forest; elsewhere litter is light or wholly lacking.

Humus.—None.

Classification of lands in T. 6 S., R. 13 E.

	Acres.
Forested	3,000
Nonforested	20,040
Badly burned	600
Logged	None.
Agricultural	None.
Grazing	12,600
Bare rocks	4,800
Tarns and streams	2,040

Total stand of timber (pole and fuel) in T. 6 S., R. 13 E.

	Cubic feet.
Lodgepole pine	1,000,000
White-bark pine	500,000
Subalpine fir	1,500,000
Engelmann spruce	2,800,000
Total	5,800,000

Composition of forest in T. 6 S., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	10
White-bark pine	9
Subalpine fir	30
Engelmann spruce	51

TOWNSHIP 6 SOUTH, RANGE 14 EAST.

Topography.—The township consists chiefly of high mountains, rising to altitudes of above 11,000 feet, breaking off along the east line with steep slopes and scarps to the canyon of Stillwater River, and broadening on the west into the wide summit of Lake Plateau in the adjoining township.

Mining.—Prospects merely, situated along Stillwater Valley.

Minerals.—Copper is said to occur.

Soil.—Stony and gravelly throughout.

Agricultural adaptability.—None of the lands in the township are tillable.

Grazing capacity.—Portions of the high western areas of the township, in all 12,000 acres, are covered with a more or less continuous turf of low alpine sedges and grasses suitable for pasturage. The tracts are difficult of access and are not pastured.

Drainage conditions.—Small creeks, rivulets, and springs are abundant. Tarns and lakelets occur here and there at the head of the creeks in the western portions of the township, and snow remains on a few of the high northern slopes through the summer.

Snow and rock slides.—Frequent along the steep breaks to the Stillwater Canyon.

Towns and settlements.—None.

Forest conditions.—Wholly subalpine. The stands occur in scattered bodies of small extent along the breaks to Stillwater Canyon and as narrow fringes bordering the creeks. Most of the areas in the township are situated at or well above timber line and carry no arborescent growth.

Cutting.—None.

Burns.—None.

Reproduction.—Owing to the high altitude the reproductive capacity of the forest is low, and the young growth is insufficient in amount to stock fully the stands.

Undergrowth.—Willows, alders, and the like, small in amount.

Litter.—Light.

Humus.—None.

Classification of lands in T. 6 S., R. 14 E.

	Acres.
Forested	5,600
Nonforested	17,440
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	12,000
Bare rocks	5,000
Tarns and streams	440

Total stand of timber (pole and fuel) in T. 6 S., R. 14 E.

	Cubic feet.
Lodgepole pine	1,000,000
White-bark pine	1,500,000
Subalpine fir	800,000
Engelmann spruce	2,000,000
Total	5,300,000

Composition of forest in T. 6 S., R. 14 E., including trees of all species with basal diameters of 3 inch[illegible] upward.

	Per cent.
Lodgepole pine	25
White-bark pine	25
Subalpine fir	[illegible]
Engelmann spruce	30

TOWNSHIP 6 SOUTH, RANGE 15 EAST.

Topography.—The central and southern areas of the township comprise high, rocky slopes and summits varying from 9,000 to 11,000 feet, abounding in precipices and steep declivities. The western quarter of the township is cut by the canyon of Stillwater River, which is 3,000 to 3,500 feet below the summits of the inclosing ridges, whose slopes rise steep and precipitous from the narrow cliff-bound valley of the stream. The eastern areas are traversed by Rock Creek Canyon, a narrow rift between towering walls of rock.

Mining.—None.

Soil.—Thin, stony, and gravelly, with small admixtures of loam.

Agricultural adaptability.—None except a few small tracts in the Stillwater bottoms, 350 acres in all.

Grazing capacity.—None.

Drainage conditions.—The run-off is of moderate volume and is carried by Stillwater River and Rock Creek, both of which are utilized for irrigation purposes on lands situated in townships adjoining on the north. Many of the high northern slopes carry banks of snow throughout the summer.

Snow and rock slides.—Frequent along the steep breaks of Stillwater River and Rock Creek.

Towns and settlements.—No towns exist in the region. There are two or three farmsteads in Stillwater Valley.

Forest conditions.—The forest is chiefly of the subalpine type. It occurs in thin, scattering stands on the rocky slopes and in small compact bodies here and there on the summits of the lower and broader ridges. It contains little mill timber, all of very inferior quality and mostly inaccessible. It is chiefly valuable as a factor in insuring stability of slope.

Cutting.—Small quantities in Stillwater Valley have been cut for farm uses.

Burns.—Tracts in the northern areas (400 acres) have been burned over within the past seven or eight years.

Reproduction.—Low throughout, generally insufficient to maintain or increase the present stands.

Undergrowth.—Scanty; mostly composed of low-growing huckleberry shrubs.

Litter.—On the burned-over areas the litter, consisting chiefly of the unconsumed trees, is moderately abundant; elsewhere its amount is trifling.

Humus.—None.

Classification of lands in T. 6 S., R. 15 E.

	Acres.
Forested	9,100
Nonforested	13,940
Badly burned	400
Logged	None.
Agricultural	350
Grazing	None.
Bare rocks and alpine areas	13,100
Lakes, tarns, and streams	90

Total stand of timber in T. 6 S., R. 15 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	1,000,000	2,500,000	2,680,000
White-bark pine		1,500,000	1,500,000
Subalpine fir		1,400,000	1,400,000
Engelmann spruce	500,000	600,000	690,000
Total	1,500,000	6,000,000	6,270,000

Composition of forest in T. 6 S., R. 15 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	34
White-bark pine	28
Subalpine fir	30
Engelmann spruce	8

TOWNSHIP 6 SOUTH, RANGE 16 EAST.

Topography.—The southern areas of the district comprise rough mountains rising to altitudes of 12,500 feet, bristling with crags and rocky, inaccessible heights. In the central areas are the northern fronts and spurs of this mass of mountains, which, in the northern end of the township, sink into a narrow fringe of foothill country.

Mining.—None.

Soil.—Sand, gravel, and bowlders, with thin toppings of loam.

Agricultural adaptability.—None; the land is too stony, its slopes too steep, and its altitude too great for agriculture.

Grazing capacity.—The grazing lands consist of ancient fire glades situated in the northern part of the township that have failed to restock.

Drainage conditions.—The township in part forms the water head of Fishtail Creek, besides giving rise to numerous smaller streams. A large amount of rainfall originates in its high southern areas. The northern slopes situated above the 10,500-foot level carry banks of snow throughout the summer.

Snow and rock slides.—Not infrequent in the upper portions of Fishtail Canyon.

Towns and settlements.—None.

Forest conditions.—The foothills and lower portions of the central areas are stocked with exceedingly close-set sapling stands of aspen and lodgepole pine—reforestations after fires that occurred thirty to fifty years ago. The higher slopes bear low and scrubby stands of subalpine species, and scattered patches of old-growth lodgepole pine at middle elevations.

Cutting.—For domestic use, fuel and fencing, the dead and fallen timber on 1,500 acres has been more or less completely removed.

Burns.—A large tract in the southeast and another in the northwest corner of the township have been burned over and the timber thereon entirely destroyed.

Reproduction.—The sapling stands of lodgepole and aspen at the lower elevations are fully stocked, and any further seedling growth there is impossible. The burned-over areas are not reforesting, or but very scantily. In the subalpine stands young growth is sparse.

Undergrowth.—In the forested areas there is very little underbrush. On the burns *Ceanothus* and other shrubs are springing up profusely.

Litter.—Light.

Humus.—None.

Classification of lands in T. 6 S., R. 16 E.

	Acres.
Forested (sapling stands, 9,000 acres)	13,040
Nonforested	10,000
Badly burned	3,000
Logged	None.
Agricultural	None.
Grazing	2,000
Bare rocks	5,000

Total stand of timber in T. 6 S., R. 16 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	2,500,000	3,000,000	3,450,000
White-bark pine		500,000	500,000
Subalpine fir		2,300,000	2,300,000
Engelmann spruce	1,200,000	1,000,000	1,216,000
Total	3,700,000	6,800,000	7,466,000

Composition of forest in T. 6 S., R. 16 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	62
White-bark pine	8
Subalpine fir	14
Engelmann spruce	14
Aspen and cottonwood	2

TOWNSHIP 6 SOUTH, RANGE 17 EAST.

Topography.—The township consists of a rolling foothill region in the northern and east-central areas, having an altitude of 5,500 to 6,000 feet, and of rough, rocky mountain spurs in the remainder. The more northern and eastern foothills are low and gently rolling; the western rise to long combs and swells separated by wide canyons with gentle slopes.

Mining.—None.

Soil.—Deep loam in the creek bottoms; thin, gravelly, and excessively strewn with bowlders on the uplands. The central areas throughout, and the lower slopes and valleys in the southern, are deeply buried under a mantle of bowlders.

Agricultural adaptability.—The creek bottoms in the central and northern areas are arable and generally cultivated. The uplands are mostly too stony for agriculture.

Grazing capacity.—The uplands in the central and northern areas are grazing lands. Where not under fence they have been excessively overgrazed.

Drainage conditions.—The outflow originating in the township is of small volume and has its rise in various small springs. West Rosebud Creek carries most of the drainage of the township. Its waters are used for irrigation.

Snow and rock slides.—These occur only in the southwest corner of the township and are not of frequent occurrence.

Towns and settlements.—The agricultural lands are occupied. There are no towns or villages in the township.

Forest conditions.—Formerly the extreme southern and most of the western areas were forested. Fires have swept the timber out of existence, with the exception of 1,000 acres in the valley of West Rosebud Creek. The stands on this tract consist of thin lines of scrubby yellow pine and red fir, with small proportions of limber pine and a low growth of aspen.

Woodlands.—Before the advent of white settlers about one-half of the township was covered with a scattering growth of lodgepole pine, limber and yellow pine, and large, compact aspen stands. Cutting has diminished the woodland area and thinned the stands, until only 2,000 acres remain that bear timber enough to be classed as woodland. The growth is everywhere thin and scrubby.

Cutting.—The entire township, with the exception of small tracts along the south line, has been culled over. Systematic cutting is confined to the lower foothills and to the valley of the West Rosebud, where 50 per cent has been cut out. Most of the timber taken has been fuel and pole stuff; the valley has, however, supplied saw timber.

Burns.—The foothills in the central areas and all of the southern tracts have been badly burned over and the timber on them almost totally destroyed. The foothills carried stands chiefly composed of aspen; the mountain areas were clothed with lodgepole pine.

Reproduction.—The burned-over forest lands are reforesting very slowly, and the young growth is largely composed of aspen at the lower elevations, and of lodgepole pine at the middle and the highest altitudes. In the woodlands aspen is almost the sole component in the young growth.

Undergrowth.—Thin and low.

Litter.—Light.

Humus.—None.

Classification of lands in T. 6 S., R. 17 E.

	Acres.
Forested area	1,000
Woodland area	2,000
Nontimbered area	20,040
Badly burned	7,000
Logged	1,500
Agricultural (grazing)	13,040

Total stand of timber in T. 6 S., R. 17 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		225,000	225,000
Lodgepole pine		330,000	330,000
Yellow pine	80,000	90,000	104,400
Red fir		60,000	60,000
Aspen and cottonwood		50,000	50,000
Total	80,000	755,000	769,400

Composition of forest and woodland in T. 6 S., R. 17 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	45
Lodgepole pine	10
Yellow pine	38
Red fir	.5
Aspen and cottonwood	6.5

TOWNSHIP 6 SOUTH, RANGE 18 EAST.

This township consists of a rolling tract of country; low swells and ridges alternate with shallow draws and canyons. It contains no forest land. Aspen and willow groves line the streams. The uplands are utilized for grazing purposes, and the creek bottoms and swales for agriculture. It is distinctly a grazing and agricultural tract and is of no value for forestry purposes.

TOWNSHIP 7 SOUTH, RANGE 10 EAST.

Topography.—With the exception of a small area in the central portion, the township consists of narrow-crested and precipitous ridges and divides attaining altitudes of nearly 11,000 feet. The exception to the high relief is a broad canyon, a tributary of the Middle Fork of Mill Creek, cutting into the central areas of the township from the north.

Mining.—None.

Soil.—Gravel, with thin surface layers of loam; very stony and bowlder-strewn on the slopes and in the bottoms of the canyons.

Agricultural adaptability.—No portion is fit for agriculture; the tract is too stony and the altitude too great.

Grazing capacity.—The subalpine and alpine areas are mostly grassy and suitable for sheep pasture, but are practically inaccessible.

Drainage conditions.—The run-off is large and is carried by tributaries of Mill Creek. Lakelets and tarns are lacking, but the tract is well supplied with springs, marshy tracts, and creeks, and forms a natural reservoir for much of the Mill Creek flow.

Snow and rock slides.—Infrequent.

Towns and settlements.—None.

Forest conditions.—The forested areas are confined to the canyons in the central portions of the township, the high areas on the north, east, and south being situated above timber line. The stands are of medium density, thinning out near the 9,500-foot contour to small copses and narrow lines. In the lower areas lodgepole pine and Engelmann spruce are the prevailing species, largely in old growth stands. At higher altitudes the typical subalpine forest constitutes the stands. The timber is accessible by way of Mill Creek, but only with great difficulty and expense.

Cutting.—None.

Burns.—None.

Reproduction.—Deficient in the subalpine areas but abundant in the stands on the lower elevations. Most of the young growth is composed of spruce.

Undergrowth.—Light.

Litter.—There is a small amount in the stands in the canyon bottoms; very little in the stands on the subalpine areas.

Humus.—There is a thin layer of moss and pine needles.

Classification of lands in T. 7 S., R. 10 E.

	Acres.
Forested	8,320
Nonforested	14,720
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing (alpine tracts)	14,720

Total stand of timber in T. 7 S., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total stand of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	8,000,000	10,000,000	11,440,000
White bark pine		3,000,000	3,000,000
Subalpine fir		2,000,000	2,000,000
Engelmann spruce	6,500,000	5,000,000	6,170,000
Total	14,500,000	20,000,000	22,610,000

Composition of forest in T. 7 S., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	55
White bark pine	7
Subalpine fir	10
Engelmann spruce	28

TOWNSHIP 7 SOUTH, RANGE 11 EAST.

Topography.—The eastern, northern, and western areas of this township lie wholly on the summit of the main divide of the Absaroka Range, and consist of alpine and subalpine tracts rising to elevations of nearly 11,000 feet. The region is one of narrow, sharp-crested ridges, steep slopes, and bold precipitous breaks and escarpments. The central areas of the tract form the head of Hell Roaring Creek and consist of open canyons, with slopes of comparatively easy gradients in most localities.

Mining.—None.

Soil.—Gravelly and stony, with thin surface dressings of loam.

Agricultural adaptability.—The township has no arable land.

Grazing capacity.—The pasture areas of the township are limited to the summits and high slopes of the ridges, which carry a more or less close and continuous sward of alpine sedges and grasses. The tracts are difficult of access and are not now pastured, although formerly, it is said, sheep were grazed on them.

Drainage conditions.—The run-off from the township is large and is carried in part by Boulder River and in part by Hell Roaring Creek. The township contains few tarns and lakelets, but abounds in springs and rivulets. Snow lies on the high northern slopes throughout the summer.

Snow and rock slides.—Near the crests of the mountains avalanches are common.

Towns and settlements.—None.

Forest conditions.—The forest consists of thin subalpine stands of white-bark pine and spruce at the higher and the middle elevations. In the canyon of Hell Roaring Creek the forest is mostly made up of old-growth stands of lodgepole pine mixed with spruce.

Cutting.—None.

Burns.—None.

Reproduction.—Reproduction is generally deficient in the subalpine stands. The lodgepole-pine stands in the lower portions of the canyons are mostly stocked too close for any further additions.

Undergrowth.—Light.

Litter.—The subalpine forest contains very little litter. In the lodgepole-pine stands it is abundant, and is composed of trees killed by overcrowding.

Humus.—None.

Classification of lands in T. 7 S., R. 11 E.

	Acres.
Forested	10,040
Nonforested	13,000
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing and alpine	10,000
Bare rocks	3,000

Total stand of timber in T. 7 S., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total stand of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	6,600,000	9,000,000	10,188,000
White-bark pine		1,200,000	1,200,000
Subalpine fir		2,700,000	2,700,000
Engelmann spruce	4,000,000	3,500,000	4,220,000
Total	10,600,000	16,400,000	18,308,000

Composition of forest in T. 7 S., R. 11 E., including trees of all species with bas[illegible] and upward.

	Per cent.
Lodgepole pine	58
White-bark pine	4
Subalpine fir	8
Engelmann spruce	30

TOWNSHIP 7 SOUTH, RANGE 12 EAST.

Topography.—High, steep, precipitous mountains reaching elevations of 11,200 feet, a part of the main range of the Absarokas, are found in the southern and in most of the central areas of the township. The remainder consists of portions of the narrow and rocky upper canyon of Boulder River, of steep spurs abutting on this canyon, and, in the northeast quarter, of terraces or small plateau-like areas lying at the head of the West Boulder at altitudes of 9,000 to 9,500 feet.

Mining.—Boulder Valley in this township contains two mining camps—Independence and Cowles. Independence is abandoned, but Cowles is in active operation. The gravels in the central areas of the township are auriferous, and hundreds of placer claims have been located on them, a few of which are being worked.

Minerals.—Gold.

Soil.—Gravelly loam, mostly stony and mixed with bowlder drift. In places the soil is clayey or gumbo-like.

Agricultural adaptability.—No portion of the township is cultivable. The stony soil and the high altitude of the region are prohibitive of agriculture.

Grazing capacity.—Numerous alpine and subalpine glades occur throughout the township. They bear close swards of sedge and grass. Accessible in most places, they are pastured only by the animals of prospectors and by small bands of stock.

Drainage conditions.—The principal water head of Boulder River is in this township, and as such its watershedding capacity is of great importance. The run-off is large. Tarns, rivulets, and creeks are numerous. Most of the feeders to the different creeks head in glacial cirques, which commonly hold one or more tarns, forming extensive series of natural reservoirs.

Snow and rock slides.—Avalanches of rock and snow are frequent throughout, more particularly on the eastern slopes of Boulder Canyon.

Towns and settlements.—Cowles mining camp in Boulder Valley, near Haystack Peak, a stamp mill working the auriferous ores of the region, with the necessary buildings for employees clustered around it, and one small sawmill near the north line of the township in Boulder Canyon, comprise the settlements. Numerous miners' cabins are scattered over the mineral-bearing areas.

Forest conditions.—At the higher elevations the forest consists of thin subalpine stands very much scattered among the grassy glades. The timber is low and scrubby, fit chiefly for fuel and mine props. The canyon of the Boulder, and especially the tributary canyons coming in from the west, contains close-set stands of lodgepole pine and spruce varying in age from 100 to 200 years.

Cutting.—A great quantity of timber has been cut in Boulder Valley, particularly around the deserted mining camp of Independence and at Cowles camp. At the latter place the subalpine slopes are being completely stripped of every vestige of timber large enough to supply fuel to the mines and to the stamp mill, where steam is used for motive power.

Burns.—Large tracts in the valley of the Boulder and in the northeast quarter have been burned over during the past eight or ten years. The timber on the burned tracts has in most cases been totally destroyed.

Reproduction.—The young growth throughout is scanty and scattered. There is little restockage in the burns.

Undergrowth.—Light.

Litter.—In the stands on the west of Boulder Canyon the litter, composed of fallen timber killed by overcrowding, is abundant. Elsewhere litter is light.

Humus.—On most of the slopes with northern exposures there is usually a thin moss cover. Elsewhere humus is lacking.

Classification of lands in T. 7 S., R. 12 E.

	Acres.
Forested	10,540
Nonforested	12,500
Badly burned	3,000
Logged	4,000
Agricultural	None.
Grazing	4,500
Bare rocks	3,800
Tarns	1,200

Total stand of timber in T. 7 S., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	10,000,000	12,000,000	13,800,000
White-bark pine		2,000,000	2,000,000
Red fir	1,000,000	500,000	680,000
Subalpine fir		4,000,000	4,000,000
Engelmann spruce	9,000,000	15,000,000	16,620,000
Total	20,000,000	33,500,000	37,100,000

Composition of forest in T. 7 S., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	4
Red fir	1.5
Subalpine fir	9.5
Engelmann spruce	25

TOWNSHIP 7 SOUTH, RANGE 13 EAST.

Topography.—This township is a plateau-like area situated mostly above timber line, cut by shallow canyons and dotted with numerous tarns.

Mining.—None.

Soil.—Thin gravelly loam.

Agricultural adaptability.—The township contains no tillable land.

Grazing capacity.—Most of the township is covered with a thin sward of alpine grasses and sedges which might afford a scanty pasturage during three or four months of each year.

Drainage conditions.—Owing to its elevated position the region receives a large amount of snow and rain, and the run-off is large. The tract abounds in tarns, springs, and creeks, and constitutes an important water head of Boulder and Stillwater rivers.

Snow and rock slides.—Infrequent.

Towns and settlements.—None.

Forest conditions.—The forest is of subalpine composition throughout, and consists of white-bark pine, spruce, and subalpine fir, with lodgepole pine in the southwest corner. On a small tract in this corner, the forest is set in a close, well-stocked stand; elsewhere the stands are thin, and scattered over the rough surface and slopes in narrow lines and small copses. It is chiefly an old and middle-aged growth. Except for local use the forest is inaccessible.

Cutting.—None.

Burns.—Along the west line of the township the timber on 1,200 acres has been killed by recent fires.

Reproduction.—Scanty throughout. The young growth is composed of the same species, in the same proportions as the mature forest.

Undergrowth.—There is only a very low and thin growth of underbrush in the district.

Litter.—Abundant in the southwest corner of the township, consisting of dead and fallen pole growths, killed by overcrowding.

Humus.—Thin or entirely lacking.

Classification of lands in T. 7 S., R. 13 E.

	Acres.
Forested	3,500
Nonforested	19,540
Badly burned	1,200
Logged	None.
Agricultural	None.
Grazing	12,000
Bare rocks	3,840
Lakelets and tarns	2,500

Total stand of timber in T. 7 S., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	3,000,000	3,000,000	3,540,000
White-bark pine		300,000	300,000
Subalpine fir		600,000	600,000
Engelmann spruce	2,200,000	1,000,000	1,396,000
Total	5,200,000	4,900,000	5,836,000

Composition of forest in T. 7 S., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	30
White-bark pine	5
Subalpine fir	15
Engelmann spruce	50

TOWNSHIP 7 SOUTH, RANGE 14 EAST.

Topography.—The eastern and western areas comprise steep, rocky spurs rising to elevations of 10,000 to 11,000 feet. The central areas consist of the canyon of Stillwater River and its immediate slopes. The canyon is a rocky gorge hemmed in by steep slopes, which in the southeast portion become immense, towering cliffs rising sheer from the valley 2,000 to 2,500 feet.

Mining.—None.

Soil.—Gravelly and stony, with light surface admixtures of loamy matter.

Agricultural adaptability.—None of the areas are tillable.

Grazing capacity.—The summits of the spurs are covered with a thin sward of alpine and subalpine sedge and grass. The eastern areas are practically inaccessible. The western areas can be reached, but probably only by sheep.

Drainage conditions.—The tract gives rise to numerous springs and creeks, but owing to the broken character of the region holds no lakelets.

Snow and rock slides.—Very frequent along the canyon of the Stillwater, owing to the excessively steep slopes.

Towns and settlements.—There are no settlements in the township.

Forest conditions.—The timber is confined to the canyon of Stillwater River, its larger western tributaries, and a few of the lower and less rocky slopes. The stands are composed of lodgepole pine in nearly pure growths or with large proportions of spruce and subalpine fir, and vary in age from 60 to 200 years, depending on the time that has elapsed since the last fire. The forest is practically inaccessible, except for local use.

Cutting.—None.

Burns.—None.

Reproduction.—Young growth is everywhere scanty or of only moderate volume. The proportion of the different species composing it is the same as in the old or mature growth.

Undergrowth.—Light.

Litter.—Small quantities in the younger lodgepole stands.

Humus.—A thin moss cover in the canyons comprises all the humus layer.

Classification of lands in T. 7 S., R. 14 E.

	Acres.
Forested	7,040
Nonforested	16,000
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	8,000
Bare rocks and alpine	8,000

Total stand of timber in T. 7 S., R. 14 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	6,000,000	3,000,000	4,080,000
White-bark pine		1,000,000	1,000,000
Subalpine fir		6,000,000	6,000,000
Engelmann spruce	4,000,000	6,000,000	6,720,000
Total	10,000,000	16,000,000	17,800,000

Composition of forest in T. 7 S., R. 14 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	12
White-bark pine	8
Subalpine fir	20
Engelmann spruce	60

TOWNSHIP 7 SOUTH, RANGE 15 EAST.

The township comprises a high, mostly alpine region, abounding with crags, precipices, and bare rocky peaks rising to altitudes of 12,500 feet, and deep, cliff-bound canyons. None of the areas are agricultural; none have a grazing value; none are forested; scattered trees of subalpine species grow here and there in the lower and more sheltered ravines, but as most of the region is situated above timber line, there never can be any extensions of the present amount of arborescent growth. Small tarns and ponds form heads to various creeks, and the region is of importance by reason of these natural reservoirs.

Classification of lands in T. 7 S., R. 15 E.

	Acres.
Forested	None.
Nonforested	23,040
Bare rocks and alpine	20,000
Lakelets, tarns, and streams	3,040

TOWNSHIP 7 SOUTH, RANGE 16 EAST.

Topography.—This township is in a high, mostly alpine region—a mass of crags, precipices and pinnacled ridges, which, in the northwest corner of the township, culminate in peaks rising to elevations of 12,500 feet. Winding among the steep, rocky spurs lie deep, cliff-lined canyons littered with talus and morainic débris, which here and there dams the streams and causes them to spread out and form lakes of considerable size.

Mining.—None.

Soil.—The soil is sterile and rocky. A large proportion of the tract has no soil cover.

Agricultural adaptability.—There is no tillable land in the township.

Grazing capacity.—The summits of the ridges bear, hear and there, thin swards of alpine sedges and grasses and some of the larger lakes have wet glades fringing them. None of them are accessible to stock.

Drainage conditions.—There is a large and continuous outflow, all by way of West Rosebud Creek. The township constitutes a great natural reservoir to this stream, and as such is of importance notwithstanding its rough and rocky character.

Snow and rock slides.—Frequent throughout.

Towns and settlements.—No part of the township is inhabited.

Forest conditions.—Most of the township lies above timber line, and the forest is confined to the lower slopes and the bottoms of a few canyons in the northern portion. The stands are composed of lodgepole pine and spruce at the lowest elevations, and of the subalpine type of forest at the upper.

Cutting.—None.

Burns.—Tracts in the northeast corner of the township have been burned over within the past seven or eight years and the timber on 400 acres destroyed.

Reproduction.—Young growth is not abundant. Lodgepole pine and Engelmann spruce are the leading species in the restockage. The burned-over tracts are not reforesting.

Undergrowth.—Low shrubs, of huckleberry, wild raspberry, gooseberry, etc.

Litter.—In the lodgepole-pine stands and on the burned-over areas litter of dead and fallen pole timber is abundant. In the subalpine stands the amount is small.

Humus.—None.

Classification of lands in T. 7 S., R. 16 E.

	Acres.
Forested	2,400
Nonforested	20,640
Badly burned	400
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and high alpine	17,140
Lakes and tarns	3,100

Total stand of timber (pole and fuel) in T. 7 S., R. 16. E.

	Cubic feet.
Lodgepole pine	950,000
White-bark pine	350,000
Subalpine fir	800,000
Engelmann spruce	800,000
Total	2,900,000

Composition of forest in T. 7 S., R. 16 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	50
White-bark pine	12
Subalpine fir	20
Engelmann spruce	18

TOWNSHIP 7 SOUTH, RANGE 17 EAST.

Topography.—The township consists of the divide lying betweet East and West Rosebud creeks, with the steep breaks leading into the canyons of these streams. It is a high, rugged mass of mountains, some portions rising to nearly 12,000 feet while comparatively little lies below the 9,000-foot contour.

Mining.—None.

Soil.—Very thin, gravelly loam, stony, and strewn with huge bowlders in most places. Large areas, particularly on the breaks to the Rosebud canyons, are entirely devoid of soil cover.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—In the Rosebud canyons small glades and burned-over tracts not reforesting furnish pasture and are so utilized. The summits of the spurs are covered with alpine sedges and grasses, but are inaccessible to domestic grazing animals.

Drainage conditions.—The run-off is large and continuous, and as the tract serves as a natural reservoir for the two Rosebud creeks it is of great importance.

Snow and rock slides.—These are common, especially in East Rosebud Canyon. Enormous masses of overhang line the brinks of the canyons and frequently send down vast masses of rock and gravelly débris.

Towns and settlements.—There are no towns on the tract. At the north end of East Rosebud Lake, a sheet of water covering 750 acres in the canyon of the same name, is a summer cottage belonging to a Major Armstrong, who occupies a tract of surveyed land in the heart of the mountains far from all other surveys.

Forest conditions.—The forest consists of thin stands of lodgepole pine, red fir, white-bark pine, and spruce in the canyons and on the declivities where the slope is not too steep to permit soil to accumulate. Small stands of aspen and cottonwood occur in the bottoms of East Rosebud Canyon, while a few copses of yellow pine occupy tracts at the mouth of the canyon. Formerly the bottoms and slopes of East Rosebud Canyon were closely stocked with timber in most places, but very little has escaped the fires during the last four or five years.

Cutting.—Small quantities here and there for local use.

Burns.—During the past six or seven years most of the township has been burned over. Complete destruction of the timber has followed.

Reproduction.—There is little young growth. The burned tracts show practically no evidence of reforestation. Especially is such the case on the southern and western exposures. Since the fires many of the slopes show extensive gullying, while on most of them the loamy surface is being washed into the streams and carried away, a process which will indefinitely retard reforestation.

Undergrowth.—Moderate in quantity. A few of the burns are growing up to various sorts of brush, mostly *Ceanothus.*

Litter.—There are large quantities of dead and fallen timber on the burned-over tracts. Most of the dead timber is still standing, and when it falls the amount of litter will be very large.

Humus.—None.

Classification of lands in T. 7 S., R. 17 E.

	Acres
Forested	3,600
Nonforested	19,440
Badly burned	11,440
Logged	None
Agricultural	None
Grazing	3,000
Bare rocks	4,000
Lakes and tarns	1,000

Total stand of timber (pole and fuel) in T. 7 S., R. 17 E.

	Cubic feet.
Lodgepole pine	1,200,000
White-bark pine	800,000
Yellow pine	20,000
Red fir	40,000
Subalpine fir	500,000
Engelmann spruce	500,000
Aspen and cottonwood	200,000
Total	3,260,000

Composition of forest in T. 7 S., R. 17 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	50
White-bark pine	15
Yellow pine	.2
Red fir	.8
Subalpine fir	10
Engelmann spruce	20
Aspen and cottonwood	4

TOWNSHIP 7 SOUTH, RANGE 18 EAST.

Topography.—The western half of the township consists of steep, rocky spurs forming the divide between Red Lodge and West Rocky Fork creeks, and between Red Lodge and East Rosebud drainage. Their eastern terminations lie in the central portion of the tract where they break with sharp descents to a rolling foothill region, which fills the remainder of the areas of the township with low, long ridges and a multitude of shallow ravines and gullies. The general elevation of the foothill region is about 5,600 feet, while the ridges in the western areas reach altitudes of 9,000 feet.

Mining.—No mineral is mined. Petroleum is thought to occur in the northwest quarter of the township, where borings have been made intermittently for several years, but without definite results.

Soil.—Gravelly loam. The entire foothill region is covered with a deep blanket of extremely heavy bowlder drift, partly overlain with a thin top-dressing of loamy matter.

Agricultural adaptability.—The western areas contain no tillable land. Tracts in the eastern portion, in the aggregate 800 or 1,000 acres, are susceptible of cultivation.

Grazing capacity.—The foothill region, where not wooded, has a grass cover, and has long been utilized as cattle and sheep ranges. Where not fenced it has been badly overgrazed.

Drainage conditions.—The run-off is of moderate volume, and is carried by Red Lodge, West Rocky Fork, and numerous smaller creeks, which have their rise in the fronts of the spurs. Their waters are more or less used for irrigating agricultural lands outside the township.

Snow and rock slides.—Infrequent, and limited to the high western portions.

Towns and settlements.—One or two farmsteads near the north line of the township comprise the settlements.

Forest conditions.—The mountain areas bear nearly pure-growth stands of lodgepole pine at middle elevations, giving way to stands of the ordinary subalpine type at the highest altitudes. The foothill region is dotted with extensive and extraordinarily closely set stands of sapling lodgepole pine and aspen, this young growth covering fully 60 per cent of the forested area of the township. Most of the timber in the district has only a fuel or pole value. With the exception of the summits of the spurs the different tracts are not particularly difficult of access.

Cutting.—The foothills and lower slopes of the mountains were culled many years ago. In some of the more readily accessible portions the cutting has amounted to 80 or 90 per cent. Much fire-killed timber has been taken out. In the aggregate 5,000 acres have been culled.

Burns.—Extensive forest fires, originating five or six years ago in East Rosebud Canyon, burned the timber on large tracts of the mountain spurs, but the killed trees are still standing.

Reproduction.—In the high areas there is little young growth. Parts of the burns are restocking; parts are still without any seedling growth. Lodgepole pine is the chief species in the restockage. The foothills are becoming covered with extremely close-set stands of lodgepole pine and aspen. It is impossible to determine with absolute certainty whether these stands are reforestations direct after fires, or whether they occupy ground formerly grassed over as the result of repeated fires while the Indian had control of the region. However this may be, the forest is now extending into foothill tracts which do not show a vestige of former timber growth. These heavily stocked stands of young lodgepole and aspen are the most conspicuous features of the forest.

Undergrowth.—In the stands of green timber there is very little underbrush present. On the burned-over areas which are not restocking, dense growths of shrubs, chiefly *Ceanothus*, are covering the ground.

Litter.—In the growing forest the litter generally is light; in the burned districts dead and down timber is accumulating in great quantities.

Humus.—None.

Classification of lands in T. 7 S., R. 18 E.

	Acres.
Forested	12,040
Nonforested	11,000
Badly burned	6,000
Logged (culled)	8,000
Agricultural	1,000
Grazing	3,200
Bare rocks	800

Total stand of timber in T. 7 S., R. 18 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet, B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	2,000,000	9,000,000	9,360,000
White-bark pine		1,200,000	1,200,000
Subalpine fir		900,000	900,000
Engelmann spruce	800,000	900,000	1,044,000
Aspen and cottonwood		1,000,000	1,000,000
Total	2,800,000	13,000,000	13,504,000

Composition of forest in T. 7 S., R. 18 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	Scattered trees.
Lodgepole pine	70
White-bark pine	3
Red fir	Scattered trees.
Subalpine fir	1
Engelmann spruce	6
Aspen and cottonwood	20

TOWNSHIP 8 SOUTH, RANGE 10 EAST.

Topography.—The township consists of high, rocky, alpine and subalpine ridges reaching altitudes of 10,000 feet, with deep and narrow intervening canyons belonging to the drainage basin of Hell Roaring Creek.

Mining.—None.

Soil.—Thin, gravelly, stony, and bowlder-strewn throughout.

Agricultural adaptability.—There are no lands capable of tillage in the township.

Grazing capacity.—None.

Drainage conditions.—Numerous springs, rivulets, and creeks have their rise in the township.

Snow and rock slides.—Infrequent.

Towns and settlements.—None.

Forest conditions.—The lower areas are covered with large and continuous stands of lodgepole pine, with small admixtures of spruce and red fir. The stands average 100 years old. The subalpine forest consists of white-bark pine, spruce, and subalpine fir and is thin and scattering.

Cutting.—None.

Burns.—Along the east line small patches of burns, in the aggregate 500 acres, extend into the township from the large burns in Hell Roaring Basin.

Reproduction.—Scanty, but sufficient to maintain the present density of stands. The greater portion of the sapling and seedling growth is composed of lodgepole pine.

Undergrowth.—Sparse.

Litter.—There is a moderate amount of dead and down timber, killed by overcrowding, in the lodgepole pine stands. In the subalpine forest the amount of litter is small.

Humus.—None.

Classification of lands in T. 8 S., R. 10 E.

	Acres.
Forested	16,000
Nonforested	7,040
Badly burned	500
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and high alpine	6,540

Total stand of timber in T. 8 S., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total stand of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	20,000,000	25,000,000	28,600,000
White-bark pine		8,000,000	8,000,000
Red fir	1,000,000		180,000
Subalpine fir		3,000,000	3,000,000
Engelmann spruce	5,000,000	2,000,000	2,900,000
Total	26,000,000	38,000,000	42,680,000

Composition of forest in T. 8 S., R. 10 E., including trees of all species with basa[illegible] and upward.

	Per cent.
Lodgepole pine	72
White-bark pine	10
Red fir	.3
Subalpine fir	5.7
Engelmann spruce	12

TOWNSHIP 8 SOUTH, RANGE 11 EAST.

Topography.—The tract chiefly consists of the upper basin of Hell Roaring Creek, a broad, semicircular depression between ridges having altitudes of 9,000 to 10,000 feet. The depression forms a sort of valley with low ridges, gullies, and ravines intersecting its bottom in various directions. Hell Roaring Creek is in a rift in the solid granite, 50 to 60 feet wide and 40 to 60 feet deep, with nearly perpendicular walls. The east side of the valley rises to the summit of the inclosing ridges through a series of broad terraces; the north and west sides mount on the steep fronts of high spurs stretching out from divides in the townships adjoining, while the south side forms the entrance to the canyon portion of Hell Roaring Creek Valley.

Mining.—None.

Soil.—Thin, gravelly loam, stony; many of the slopes are covered with talus devoid of soil. The surface of the central part of the depression consists of a sheet of bowlder and gravel drift.

Agricultural adaptability.—None of the lands in the township are tillable.

Grazing capacity.—The grazing areas of the township are mostly fire glades slowly reforesting. A few marshy meadows occur in the central areas, and some small subalpine glades on the ridges inclosing the valley on the east.

Drainage conditions.—A large amount of water flows from the township. The tract abounds in large springs, points of seepage, subalpine rivulets, and small ponds. It is practically the water head of Hell Roaring Creek.

Snow and rock slides.—Infrequent or altogether lacking.

Towns and settlements. —None.

Forest conditions.—The forest conditions are the results of fires during the past one hundred and fifty years. The central areas are covered chiefly with lodgepole pine, varying in age from 50 to 100 years. The younger stands are reforestations after fires in modern times; the older growths are stands that escaped the last great fires, and are scattered throughout the sapling growths. The subalpine forest, covering 30 per cent of the township, consists of spruce, white-bark pine, and subalpine fir, with occasionally some lodgepole pine. The white-bark pine is very abundant, and at the highest levels forms 75 per cent of the forest. Along the lower edge of the subalpine stands Engelmann spruce constitutes 60 to 80 per cent of the timber. The timber on the high eastern slopes of the valley is chiefly an old growth, varying from 150 to 200 years in age. Poplar and aspen groves are common in the central parts and form thick fringes around the tarns and ponds, or entirely cover the more seepy areas where coniferous growth is not possible.

Cutting.—None.

Burns.—The recent burns, not yet reforesting, or only very tardily, amount lodgepole-pine the young growth is chiefly spruce. Nearly all the forest in the township is in a very active stage of natural thinning.

Undergrowth.—The brush growth is scanty throughout.

Litter.—Here and there along Slough Creek and on Horseshoe Mountain the forest is quite free from litter, and presents, in the older stands, a clean, park-like appearance. Elsewhere in the township the forest is littered with an immense amount of dead and down pole timber, the result of overstockage.

Humus.—In the stands bordering the valley on the west a layer of humus or duff, 3 to 6 inches in depth, covers the forest floor. In the stands on the eastern side of the valley it is very thin or altogether lacking.

Classification of lands in T. 8 S., R. 13 E.

	Acres.
Forested	20,640
Nonforested	2,400
Badly burned	100
Logged	None.
Agricultural	None.
Grazing	1,800
Bare rocks	500

Total stand of timber in T. 8 S., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	65,000,000	64,000,000	75,700,000
White pine	3,000,000		540,000
White-bark pine		4,000,000	4,000,000
Red fir	5,000,000		900,000
Subalpine fir		5,500,000	5,500,000
Engelmann spruce	52,000,000	10,000,000	19,360,000
Total	125,000,000	83,500,000	106,000,000

Composition of forest in T. 8 S., R. 13 E., including trees of all species with basal diameters of 3 inches [illegible] upward.

	Percent.
Lodgepole pine	62
White pine	[illegible]
White-bark pine	[illegible]
Red fir	[illegible]
Subalpine fir	[illegible]
Engelmann spruce	20

TOWNSHIP 8 SOUTH, RANGE 14 EAST.

Topography.—The eastern areas of the township comprise a high, rocky, glaciated tract abounding in shallow depressions, small flats, short escarpments, steep serrated peaks, and narrow crevice-like canyons. The central areas are cut by the trough-like canyon of Stillwater River, with sheer, rock walls in most places. The western tracts consist of broad spurs and ridges stretching eastward from the main divides in the township on the west.

Mining.—None.

Soil.—Thin and gravelly; most of the nontimbered areas of the township have no soil cover.

Agricultural adaptability.—The township contains no tillable land.

Grazing capacity.—None.

Drainage conditions.—The run-off is large. The eastern half is very abundantly supplied with springs, tarns, alpine rivulets, and creeks, while several large creeks have their rise in the western areas. The township is one of the principal water heads of Stillwater River.

Snow and rock slides.—Slides are of frequent occurrence, especially in the eastern areas along the breaks to the Stillwater Canyon.

Towns and settlements.—The township is uninhabited.

Forest conditions.—The bottoms of the Stillwater canyons are forested with moderately close-set stands of lodgepole pine and Engelmann spruce, mostly old growth. The ridges west of the canyon carry stands of subalpine type, thin and scattered at the higher elevations, close set in the canyons. The eastern areas of the township are mostly bare of forest, or have thin lines of trees and small copses set here and there in the sheltered hollows of the spurs. The timber is inaccessible except for local use.

Cutting.—None.

Burns.—None.

Reproduction.—In the stands in Stillwater Valley the young growth, consisting chiefly of lodgepole pine, is sufficient to maintain the present volume. There is little young growth in the subalpine stands.

Undergrowth.—Light.

Litter.—A small quantity of dead and down timber is scattered through the forest in Stillwater Valley, a large proportion of this being due to the crushing effects of snow and rock slides descending the steep slopes. Elsewhere the litter is small in quantity.

Humus.—A light cover of moss occurs in the valley and on the lower slopes. At the higher elevations the forest floor is bare.

Classification of lands in T. 8 S., R. 14 E.

	Acres.
Forested	9,000
Nonforested	14,040
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks and alpine	13,000
Tarns and streams	1,040

Total stand of timber in T. 8 S., R. 14 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	8,000,000	10,000,000	11,440,000
White-bark pine		1,000,000	1,000,000
Subalpine fir		3,000,000	3,000,000
Engelmann spruce	20,000,000	2,000,000	5,600,000
Total	28,000,000	16,000,000	21,040,000

Composition of forest in T. 8 S., R. 14 E., including trees of all species with basal diameters of 8 inches and upward.

	Per cent.
Lodgepole pine	20
White-bark pine	6
Subalpine fir	9
Engelmann spruce	65

TOWNSHIP 8 SOUTH, RANGE 15 EAST.

Topography.—The township consists of a high alpine and subalpine area, in the southern and central portions comprising a mass of short, irregular ridges with a maze of ravines, shallow canyons, and runs cutting the ridges in all directions, and a large number of depressions holding one or more lakelets and tarns. The northern areas rise into towering peaks, several of them 12,000 feet in height, surrounding which are rock-bound canyons almost crevice-like in their narrowness.

Mining.—None; the region is mineralized, however.

Minerals.—Gold and copper.

Soil.—Thin and gravelly, in most localities strewn with immense bowlders and masses of talus. Most of the areas are entirely devoid of soil, presenting nothing but the smooth, bare rock.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—A few hundred acres of alpine meadow land exist in the southern and central areas. The tracts are not pastured.

Drainage conditions.—The township is of importance by reason of the large volumes of water constantly discharged from its areas. The tarns and lakelets constitute natural reservoirs, and great banks of snow or incipient glaciers lie on the northern slopes of most of the higher elevations. The drainage flows partly into Stillwater River and partly into Clark Fork.

Snow and rock slides.—Of frequent occurrence, especially in the northern areas. Mud slides carrying vast quantities of bowlders line many of the tarns and are common on the slopes of the peaks. The ragged and serrated crests of the ridges have enormous masses of overhang, from which avalanches of stones and bowlders are continually descending into the canyons and building up the talus slopes.

Towns and settlements.—None.

Forest conditions.—The tract carries no forest. There are a few trees of white-bark pine and Engelmann spruce scattered through the hollows or lining the tarns in the southern areas. Most of the township lies at altitudes above timber line, where low growths of willows replace arborescent vegetation.

Reproduction.—Climatic conditions are such that much young growth is impossible. In the sheltered hollows and ravines, up to elevations of 9,800 feet, there will always be a few seedlings and saplings. Very rarely will one of them grow to maturity, being broken off or uprooted by heavy snows and fierce gales as soon as any considerable size and spread of limbs are attained.

Classification of lands in T. 8 S., R. 15 E.

	Acres.
Forested	None.
Nonforested	23,040
Agricultural	None.
Grazing	3,000
Bare rocks, alpine snowbanks, and incipient glaciers	18,000
Lakelets, tarns, and streams	2,040

TOWNSHIP 8 SOUTH, RANGE 16 EAST.

The township consists of a high, rugged mass of mountains, mostly situated above the 9,500-foot contour, with peaks and ridges rising to 12,900 feet. It abounds with peaks, serrated and pinnacled crests and ridges, canyons, precipices, and alpine lakelets and tarns.

The township is uninhabited. The surface consists chiefly of bare rock. None of the areas are agricultural in character. Swampy meadows, fringing the alpine tarns, are met with here and there, but they are practically inaccessible to stock.

None of the lands are mineral bearing. No forest exists in the township, but a few narrow lines of spruce and white-bark pine fringe tarns situated at or near the 9,500-foot contour line. The greater portion of the tract lies above timber line. The township has a large run-off, and is of importance by reason of the large natural storage capacity afforded by its many lakelets and tarns.

Classification of lands in T. 8 S., R. 16 E.

	Acres.
Forested	None.
Nonforested	23,040
Bare rocks	17,000
Alpine meadows and glades	2,540
Lakelets, tarns, and streams	3,500

TOWNSHIP 8 SOUTH, RANGE 17 EAST.

Topography.—The eastern area comprises high spurs with broadening or plateau-like summits, which in the central portion break off to the canyon of the East Rosebud. The portion of this canyon situated within the township is a mere rift through the mountains, bounded on either side by great, bare, almost perpendicular walls of rock. The southwest corner of the township rises in a vast mass of jagged cliffs. The average altitude of the township is about 10,800 feet, while many isolated tracts attain elevations of 12,000 feet.

Mining.—None.

Soil.—Thin gravelly loam, with the surface strewn with bowlders, usually of large size. The slopes leading to the different canyons are mostly bare of soil, presenting either naked rock or talus.

Agricultural adaptability.—No portion of the township has any arable land.

Grazing capacity.—The summits of the ridges are covered with a thin sward of alpine sedges and grasses. They are extremely difficult of access, probably beyond the reach of any kind of stock except sheep. There are no grazing areas in the canyons.

Drainage conditions.—The township is the water head of East Rosebud Creek. The run-off is large. Springs abound, while numerous tarns and ponds in the southern part serve as natural reservoirs and more or less regulate the outflow. The waters of East Rosebud Creek are largely utilized for irrigation purposes in the agricultural sections north of this township.

Snow and rock slides.—Of common occurrence.

Towns and settlements.—The tract is entirely uninhabited.

Forest conditions.—Light stands of lodgepole pine, spruce, and subalpine fir occur in the bottom of East Rosebud Canyon for a distance of 8 miles south from the north line of the township. Small copses and thin lines of spruce and white-bark pine cling to the rocky slopes of the different canyons or nestle in the deeper and more sheltered hollows to which projecting spur or excavated glacial cirque give rise. There is no mill timber; the growth has only a fuel value and is practically inaccessible except for local use. Most of it is a pole growth.

Cutting.—None.

Burns.—None.

Reproduction.—Reproduction is sufficient to maintain present stands. Climatic conditions forbid any considerable additions to the present timbered area, but more closely stocked stands, particularly in the East Rosebud bottoms, are possible. Lodgepole pine and spruce are the leading species of the young growth.

Undergrowth.—Very thin and scattering.

Litter.—A small amount in the lodgepole-pine stands.

Humus.—Lacking.

Classification of lands in T. 8 S., R. 17 E.

	Acres.
Forested	3,000
Nonforested	20,040
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	11,000
Bare rocks	7,300
Tarns and streams	1,740

Total stand of timber in T. 8 S., R. 17 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine		1,000,000	000,000
White-bark pine		250,000	250,000
Subalpine fir		350,000	350,000
Engelmann spruce		1,000,000	1,000,000
Total		2,600,000	2,600,000

Composition of forest in T. 8 S., R. 17 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	30
White-bark pine	5
Subalpine fir	30
Engelmann spruce	35

TOWNSHIP 8 SOUTH, RANGE 18 EAST.

Topography.—The township consists of a moor-like plateau nearly 11,000 feet above sea level. Its surface is elevated in long swells and depressed in broad, shallow swales. It is intersected from southwest to northeast by the extremely rocky and precipitous canyon of Rocky Fork, from which several lateral gorges cut deep into the plateau.

Mining.—None.

Soil.—Thin, gravelly loam with masses of bowlder drift scattered over the surface.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—Except the breaks to the various canyons the entire township is a grazing area. It has been closely sheeped in former years, and its present grazing value is low in consequence.

Drainage conditions.—There is a moderate outflow from the tract. A few small tarns occur on the summit of the plateau, and numerous springs and small creeks along its slopes. Many of the ravines which intersect the summit hold large banks of snow on their northern slopes throughout the summer, which supply various runs and rivulets with moderate volumes of water.

Snow and rock slides.—Avalanches of rock and snow, and landslips, are of frequent occurrence along the breaks of Rocky Fork Canyon and its lateral gorges.

Towns and settlements.—None.

Forest conditions.—Most of the tract is situated above timber line, and the small amount of forest is confined to the lower breaks and bottoms of the canyons. It is almost wholly of the subalpine type. The stands are thin and scattering, and are chiefly valuable for fuel. They are generally inaccessible except for local use.

Cutting.—None.

Burns.—Burned-over tracts occur in Rocky Fork Canyon and in the northwest corner of the township. The fires in Rocky Fork Canyon apparently burned six or seven years ago, and practically wiped out all the timber in the central portion of the canyon and in its northern laterals.

Reproduction.—Very scanty throughout. The burns are not yet restocking.

Undergrowth.—Scarcely any.

Litter.—Abundant on the burned-over tracts; light in other places.

Humus.—None.

Classification of lands in T. 8 S., R. 18 E.

	Acres.
Forested	2,000
Nonforested	21,040
Badly burned	1,000
Logged	None.
Agricultural	None.
Grazing	13,800
Bare rocks	8,100
Tarns and streams	140

Total stand of timber in T. 8 S., R. 18 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
White-bark pine		1,500,000	1,500,000
Subalpine fir		500,000	500,000
Engelmann spruce	500,000	800,000	890,000
Total	500,000	2,800,000	2,890,000

Composition of forest in T. 8 S., R. 18 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	10
White-bark pine	40
Subalpine fir	20
Engelmann spruce	30

TOWNSHIP 8 SOUTH, RANGE 19 EAST.

Topography.—The southern portion of the township is situated on the summit of Beartooth Plateau, and comprises a rolling tract of country at an average altitude of 9,800 feet. The central areas are made up of steep slopes and narrow, short spurs stretching north from the rim of the Beartooth Plateau into the canyon of Rocky Fork, which occupies the northern part of the township and marks the termination of the plateau in this direction. The canyon is a narrow valley, sunk nearly 4,000 feet below the summit of the plateau level on the south, and nearly 3,000 feet below the crest of the inclosing ridge on the north. The sides rise steeply, but not precipitously, to the crests, on the south making access possible to the summit of Beartooth Plateau. The valley is littered with great accumulations of heavy, glacial, bowlder drift.

Mining.—None.

Soil.—Gravelly loam, stony, and bowlder strewn.

Agricultural adaptability.—The tillable land is confined to 150 acres in Rocky Fork Canyon.

Grazing capacity.—The southern areas, situated on the summit of the plateau, and small glades in the Rocky Fork bottoms, comprise the grazing areas. They have been closely sheeped in former years and their present pasturage value is small.

Drainage conditions.—The outflow originating in the township is comparatively small. It is carried by Rocky Fork Creek, and is used for irrigation enterprises and for domestic supply in the town of Red Lodge, in the township adjoining on the east.

Snow and rock slides.—Most of the slopes in the district having long ago acquired stability and a forest cover, avalanches either of snow or of rock are infrequent.

Towns and settlements.—The district has no towns. Two or three small farmsteads in Rocky Fork Canyon comprise all of the settlements.

Forest conditions.—Most of the northern slopes, where not burned over, carry close-set stands of timber, 80 per cent of which is in the sapling stage and represents restockage after burns thirty-five to fifty years ago. At the higher elevations 75 per cent of this young growth is composed of white-bark pine, the balance being lodgepole pine and spruce. The southern slopes have been nearly deforested by fires in recent years, and carry only scattered stands of lodgepole pine, mostly in the sapling stage. At the lowest elevations on all slopes lodgepole pine is the prevailing species, red fir and limber pine constituting only a small proportion.

Cutting.—Small tracts bordering Rocky Fork Canyon have been cut over for fencing, mine timber, and fuel.

Burns.—Most of the southern, and some small tracts on the northern, slopes have been burned over, apparently six or seven years ago.

Reproduction.—The sapling stands are generally so fully stocked that further additions are impossible. In the mature stands there is a moderate amount of young growth. The recent burns are restocking scantily. Lodgepole pine predominates in all of the young growth, seedling and sapling, at low and middle elevations; white-bark pine prevails at the highest altitudes.

Undergrowth.—Light.

Litter.—There is a very great amount of dead and fallen pole timber, both in the green and in the burned stands. The accumulations are constantly increasing by further downfalls of the fire-killed trees.

Humus.—None.

Classification of lands in T. 8 S., R. 19 E.

	Acres
Forested	10,240
Nonforested	12,800
Badly burned	5,400
Logged	900
Agricultural	150
Grazing	[illegible]

Total stand of timber in T. 8 S., R. 19 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		30,000	30,000
Lodgepole pine	3,500,000	10,000,000	10,630,000
White-bark pine		2,600,000	2,600,000
Red fir	350,000	600,000	663,000
Subalpine fir		250,000	250,000
Engelmann spruce	800,000	1,200,000	1,344,000
Total	4,650,000	14,680,000	15,517,000

Composition of forest in T. 8 S., R. 19 E., including trees of all species with basal diameters of 8 inches and upward.

	Per cent.
Limber pine	0.1
Lodgepole pine	52
White-bark pine	18
Red fir	.3
Subalpine fir	15.5
Engelmann spruce	14.1

Township 9 South, Range 10 East.

Topography.—Of this township only the northern and central areas, in the aggregate 15,360 acres, belong to the reserve, the southern portion lying within the boundaries of Yellowstone National Park. The eastern part consists of the central, or canyon, portion of Hell Roaring Creek Basin, here a narrow valley, 200 to 300 yards wide at the bottom, sunk 1,500 to 2,000 feet below the summits of the inclosing ridges. The eastern wall rises steep and rocky, with long talus slopes devoid of soil, the western wall less abruptly, precipitous only here and there, and more or less terraced. The western half comprises high, rough ridges sloping into Crevice Gulch along the western line of the township.

Mining.—Placer and quartz in Crevice Gulch.

Minerals.—Gold.

Soil.—Stony and gravelly throughout; top dressing of loam thin, except around marshy places in Hell Roaring Canyon. In Hell Roaring Canyon are two lower terraces, 75 to 110 feet in height above the stream level, chiefly composed of coarse, heavy, bowlder drift.

Agricultural adaptability.—The township contains no tillable land.

Grazing capacity.—Small, and limited to wet glades in the bottom of Hell Roaring Canyon.

Drainage conditions.—The run-off of Hell Roaring Creek Basin is large. The valley is well supplied with springs and points of seepage. The flow in Crevice

Gulch is small and intermittent. None of the streams supply water for irrigation purposes.

Snow and rock slides.—Frequent in Hell Roaring Canyon.

Towns and settlements.—Miners' cabins along Crevice Gulch; no towns.

Forest conditions.—The western portion of the township is well stocked with close-set lodgepole-pine stands 75 to 150 years old, except the lower areas of Crevice Gulch, where young or middle-aged red-fir stands predominate. The forest in Hell Roaring Canyon consists of red fir, with stands of nearly pure-growth lodgepole pine 75 to 90 years old, these lodgepole-pine stands representing burns of that age. The red fir is of small dimensions, limby and stocky, 16 to 24 inches in diameter, 50 to 75 feet in height. Engelmann spruce occurs in small quantities throughout. Close-set aspen groves cover most of the swampy and springy tracts in Hell Roaring Canyon.

Cutting.—Small quantities in Crevice Gulch for local use.

Burns.—Small burns, aggregating 200 acres, occur in the northeast corner of the township on the slopes of Hell Roaring Canyon.

Reproduction.—Sufficient to maintain the present density and composition of the forest.

Undergrowth.—Small in quantity, consisting of the common low-growing shrubs of the region, chiefly huckleberry and *Shepherdia.*

Litter.—Moderate, consisting of dead and fallen timber.

Humus.—A thin layer of decaying pine needles.

Classification of lands in T. 9 S., R. 10 E.

	Acres.
Forested	13,240
Nonforested	2,120
Badly burned	200
Logged	None.
Agricultural	None.
Grazing	None.
Bare rocks	1,920

Total stand of timber in T. 9 S., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	12,000,000	26,000,000	28,160,000
White-bark pine	1,000,000	1,000,000	1,180,000
Red fir	30,000,000	8,000,000	[illegible]
Subalpine fir		[illegible]	[illegible]
Engelmann spruce	3,500,000	[illegible]	[illegible]
Aspen and cottonwood		[illegible]	[illegible]
Total	46,500,000	[illegible]	[illegible]

Composition of forest in T. 9 S., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	25
White-bark pine	1.5
Red fir	65
Subalpine fir	2
Engelmann spruce	6
Aspen and cottonwood	.5

TOWNSHIP 9 SOUTH, RANGE 11 EAST.

Topography.—The portion of the township within the forest reserve comprises 15,360 acres, the two southern tiers of sections being situated within the Yellowstone National Park. The eastern areas of the township consist of terraced breaks and slopes leading into the valley of Buffalo Creek. The central portions comprise tracts situated on the summit of Buffalo Plateau—a narrow, undulating table-land intersected with numerous low combs and ridges of rock and dotted by lakelets and tarns. The western portion is formed by terraces and slopes leading from the summit of Buffalo Plateau into Hell Roaring Canyon, sharp, precipitous breaks marking the last descent to the bottom of that valley. The altitudinal range varies from 7,200 to 9,500 feet.

Mining.—None.

Soil.—Gravelly loam, stony, with much bowlder drift throughout.

Agricultural adaptability.—None of the lands in the township are tillable, being too stony and at too high altitude for agricultural purposes.

Grazing capacity.—The grazing lands of the township comprise 4,000 acres and consist of grassy glades, in part swampy, in Buffalo Canyon and on its terraced western slopes, of level and rolling grass- and sedge-covered summits of the plateau area, and of fire glades, scantily reforesting, on the western slope of the plateau. The grazing areas have been moderately sheeped in the past, but were not used by any kind of stock in the summer of 1903.

Drainage conditions.—The run-off is large. The township is a sort of natural reservoir to the lower portions of Hell Roaring and Buffalo creeks. Pools, ponds, marshy tracts, springs, and rivulets abound throughout its area. The summit of Buffalo Plateau is remarkably well supplied with springs and ponds.

Snow and rock slides.—Apparently not frequent.

Towns and settlements.—None.

Forest conditions.—Most of the stands in the township consist of old growths, 100 to 150 years old. The eastern areas are forested with close-set stands of lodgepole pine, pure or mixed with spruce, or occasionally, at the lower elevations, with red fir. The forest on the summit of Buffalo Plateau is chiefly of the subalpine type—white-bark pine, Engelmann spruce, and subalpine fir, the spruce predominating. It occurs in thin lines and scattered groups with tracts of grassy glades or meadow intervening. On the slopes of Buffalo Plateau, in the western part of the township, the forest at the upper elevations consists of 75 per cent white-bark pine and 25 per cent Engelmann spruce, much of the white-bark pine forming trees 20 to 30 inches basal diameter and 20 to 35 feet clear trunk. At middle elevations the forest is chiefly made up of close-set stands of Engelmann spruce, the trees being 2 to 4 feet in diameter and 30 to 50 feet clear trunk, while the lowest terraces bear uneven-aged stands of lodgepole pine, from 50 to 150 years old, thinly set or in more closely stocked, scattered stands separated by old fire glades. All of the timber in the township is difficult of access for logging operations.

Cutting.—None.

Burns.—Recent burns amount to only 350 acres. Burns sixty to eighty years ago laid waste 4,000 acres, now partly reforesting.

Reproduction.—The reproductive capacity of the subalpine forest on the summit of Buffalo Plateau is low. The wide grassy tracts which occur here are wholly due to past fires, and as no portion of the plateau is above timber line the forest will slowly advance and eventually reoccupy the ground, provided fires are prevented. Elsewhere in the township young growth is sufficient to maintain the present stocking of the stands, and where abnormally thin, old growths prevail abundantly enough to insure more close-set stands in the future.

Undergrowth.—Undergrowth is scanty at high elevations and in the close-set lodgepole-pine stands throughout, as well as in the old, heavy, spruce growths on the middle terraces of the western slopes of Buffalo Plateau. It is thick and abundant in the young lodgepole-pine stands on the lower western slopes of the plateau, consisting chiefly of *Shepherdia*, with small percentages of willows.

Litter.—Light, except in the spruce growths on the western slopes of the plateau, where vast quantities of uprooted trees block the forest in all directions.

Humus.—In the spruce growths above mentioned the humus layer varies from 3 to 6 inches in depth; elsewhere in the township it is light or altogether lacking.

Classification of lands in T. 9 S., R. 11 E.

	Acres.
Forested	10,360
Nonforested	5,000
Badly burned	350
Logged	None.
Agricultural	None.
Grazing	[illegible]
Bare rocks	[illegible]
Lakes, ponds, and streams	[illegible]

Total stand of timber in T. 9 S., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	8,000,000	7,500,000	8,940,000
White-bark pine	3,000,000	12,000,000	12,540,000
Subalpine fir		2,000,000	2,000,000
Engelmann spruce	27,000,000	3,500,000	8,360,000
Total	38,000,000	25,000,000	31,840,000

Composition of forest in T. 9 S., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	55
White-bark pine	15
Subalpine fir	10
Engelmann spruce	20

TOWNSHIP 9 SOUTH, RANGE 12 EAST.

Topography.—The western portions of the township comprise a part of the lower valley of Buffalo Creek, a depression with bottoms one-third mile wide and slopes rising in a succession of terraces to the summits of the inclosing ridges, which reach altitudes of 9,600 feet. The central regions comprise narrow, plateau-like areas, forming the divide between Buffalo and Slough creeks and breaking off to the latter in a succession of narrow rocky terraces. The township contains 15,360 acres, the two southern tiers of sections belonging to Yellowstone National Park.

Soil.—Gravelly loam, or clayey where derived from the lavas.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—The grazing lands consist of swales and glades on the summit of the divides in the central areas and on its slopes; in all, 500 acres.

Drainage conditions.—The tract is well supplied with springs and points of seepage, but gives rise to no creeks of notable size.

Snow and rock slides.—The declivities are too gentle and the stability of the slopes too well established for slides of any sort.

Towns and settlements.—The region is uninhabited.

Forest conditions.—The township is fairly well stocked with continuous stands of old-growth lodgepole pine, spruce, and small proportions of red fir in the lower and middle areas. Above the 9,000-foot contour the forest consists of the subalpine type, and the stands are more or less separated by small grassy glades. The tract is easily accessible from the south, or from the National Park.

Cutting.—None.

Burns.—None.

Reproduction.—There is sufficient young growth to maintain the present stands. The more aged lodgepole pine is gradually giving way to spruce.

Undergrowth.—The underbrush, composed of willows, huckleberry, *Shepherdia*, and serviceberry, is of moderate amount in the less closely stocked stands. In the old and thickset lodgepole pine it is nearly lacking.

Litter.—In the eastern areas the forest is littered with great quantities of dead and fallen timber, killed by overcrowding. The stands in the western portions of the township contain only small quantities.

Humus.—The forest floor in the eastern parts is covered with a layer of moss and pine needles 3 to 4 inches in depth. In the western areas the humus layer is thin or altogether lacking.

Classification of lands in T. 9 S., R. 12 E.

	Acres.
Forested	14,220
Nonforested	1,140
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	500
Bare rocks	640

Total stand of timber in T. 9 S., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	25,000,000	30,000,000	34,500,000
White-bark pine		1,500,000	1,500,000
Red fir	2,000,000	500,000	860,000
Subalpine fir	1,000,000	3,500,000	3,680,000
Engelmann spruce	10,000,000	5,000,000	6,800,000
Total	38,000,000	40,500,000	47,340,[illegible]

Composition of forest in T. 9 S., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

Lodgepole pine	65
White-bark pine	[illegible]
Red fir	[illegible]
Subalpine fir	[illegible]
Engelmann spruce	20

TOWNSHIP 9 SOUTH, RANGE 13 EAST.

Topography.—The eastern areas comprise high spurs radiating westward from the mountains at the head of Stillwater River, with the intervening canyons wide and having comparatively gentle slopes. The central areas consist of the valley of Slough Creek, which, in the northern part of the township, forms a wide level bottom, and, in the southern, contracts to a narrow pass, 400 to 500 yards wide. The western areas of the township are made up of long slopes, with low escarpments here and there forming narrow terraces, rising to the divide between Slough and Buffalo creeks.

Mining.—None.

Soil.—Gravelly loam, mixed with coarse bowlder drift.

Agricultural adaptability.—The level bottoms of Slough Creek, comprising 1,100 acres, are adapted to the raising of hay. There are three ranch locations on this tract. The entire area actually under cultivation amounts to 2 acres, on which timothy has been sown. The land is occupied mainly for the facilities such occupation affords for poaching on the areas of the Yellowstone National Park and for killing elk and beaver that may stray across the line into the middle Slough Creek Basin.

Grazing capacity.—Grassy glades in the Slough Creek bottom and along the larger lateral canyons, in the aggregate 2,000 acres, serve as pasture grounds. The lands are not grazed, however, except by prospectors' horses and by a dozen head of cattle owned by the three ranchers in Slough Creek Valley.

Drainage conditions.—While the tract is well supplied with springs and small creeks, the outflow originating within the boundaries of the township is not large. There are no lakelets or tarns.

Snow and rock slides.—Infrequent.

Towns and settlements.—The tract has no towns.

Forest conditions.—Thickset stands of lodgepole pine, in almost all parts of the entire township, comprise the forest. All ages, from 40 up to 200 years, are represented in the stands. In the younger growths the stands of lodgepole pine are nearly pure; in the more aged stands spruce and white-bark pine are present in considerable quantities. The timber is accessible only from the south by way of the Yellowstone National Park.

Cutting.—Small quantities have been cut for local use by the ranchers of Slough Creek Valley.

Burns.—A small area, comprising 40 acres and situated in the north-central portion, has been burned over recently.

Reproduction.—Young growth is abundant throughout all of the stands. The more aged lodgepole-pine growths are gradually being supplanted by spruce and subalpine fir.

Undergrowth.—Underbrush is light at the higher elevations. In the bottoms and along the lower slopes it is abundant.

Litter.—The forest in all directions is littered with large quantities of dead and fallen timber. The timber has been killed in part by overcrowding and in part by fires dating back fifty years or more.

Humus.—Generally thin in all parts of the township, and composed mostly of a light layer of moss and pine needles.

Classification of lands in T. 9 S., R. 13 E.[a]

	Acres.
Forested	11,320
Nonforested	4,040
Badly burned	40
Logged	None.
Agricultural	None.
Grazing	3,100
Bare rocks	900

Total stand of timber in T. 9 S., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	32,000,000	34,000,000	39,760,000
White-bark pine	1,000,000	1,000,000	1,180,000
Subalpine fir		5,000,000	5,000,000
Engelmann spruce	24,000,000	5,000,000	9,320,000
Total	57,000,000	45,000,000	55,260.000

Composition of forest in T. 9 S., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	3
Red fir	.2
Subalpine fir	7
Engelmann spruce	29.8

TOWNSHIP 9 SOUTH, RANGE 14 EAST.

Topography.—Of this township only 15,360 acres are in the area discussed, the two southern tiers of sections, or 7,680 acres, being in Yellowstone National Park. The western, southern, and eastern portions of the township consist of steep, rough mountains from 8,000 to 10,000 feet in altitude, abounding in precipitous slopes and craggy crests; the central areas comprise low, broad, swampy, and terraced tracts around the head of Stillwater River.

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[a] Twelve sections of this township, or 7,680 acres, are in the Yellowstone National Park, and are not included in the land classification or the timber estimates.

Mining.—The region is mineral bearing throughout.

Minerals.—Gold, silver, copper, lead.

Soil.—Thin top-dressings of loam here and there, generally gravelly and bowlder strewn; many of the steeper slopes entirely bare of soil. Deep, loamy soil exists in the more swampy areas of the central sections.

Agricultural adaptability.—The altitude of the region is too great for agriculture.

Grazing capacity.—In the aggregate, 6,000 acres of the tract are grass lands. They comprise glades, open, nonforested mountain slopes, swampy alpine meadows, especially at the head of Stillwater River, sedge, and grass-covered crests above timber line.

Drainage conditions.—The region abounds in springs, alpine and subalpine rivulets, and marshy tracts. It contains the ultimate heads of Stillwater River, several of the southern heads of Clark Fork, and the heads of numerous creeks flowing south into the Yellowstone. The volume of run-off is large and continuous, and the tract is of great importance by reason of its water-shedding capacity.

Snow and rock slides.—Frequent along all the steeper slopes.

Towns and settlements.—Miner's claims and cabins are numerous in the eastern part of the township. Cooke City, an old and nearly dead mining camp, is said to be situated in the southeast corner of the township, an assertion the correctness of which depends on the accuracy of certain surveys.

Forest conditions.—The subalpine type of forest prevails throughout the township. Engelmann spruce is the leading species. The timber generally is small, limby, and knotty, scattered in small stands, copses, and lines. The heaviest growths are in the eastern sections. There is little young or sapling growth, most of the timber running from 100 to 175 years in age. As a source of local timber supply the forest is of great importance, although the quality of its products ranges low.

Cutting.—Most of the forest in the east half of the township has been culled and cut over by prospectors and miners, the cut amounting to 10 per cent.

Burns.—A few recent burns are scattered throughout the east half of the township, in the aggregate amounting to 200 acres.

Reproduction.—Slow and scanty throughout, as is usually the condition in the higher subalpine forest in this region.

Undergrowth.—Small in quantity and composed of low-growing huckleberry shrubs to the extent of 75 per cent.

Litter.—Trifling in amount in the lower portions, almost lacking in the upper areas of the forest.

Humus.—None.

Classification of lands in T. 9 S., R. 14 E.

	Acres.
Forested	5,360
Nonforested	10,000
Badly burned	200
Logged and culled	4,000
Agricultural	None.
Grazing	6,000
Bare rocks	3,000
Lakelets and tarns	800

Total stand of timber in T. 9 S., R. 14 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	3,000,000	4,000,000	4,540,000
White-bark pine		800,000	800,000
Subalpine fir		4,500,000	4,500,000
Engelmann spruce	18,500,000	5,000,000	8,330,000
Total	21,500,000	14,300,000	18,170,000

Composition of forest in T. 9 S., R. 14 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	5
White-bark pine	5
Subalpine fir	30
Engelmann spruce	60

TOWNSHIP 9 SOUTH, RANGE 15 EAST.

Topography.—With the exception of the southeast quarter, which is a region of low relief, this township comprises a mass of rugged mountains rising to elevations of 11,000 feet in the southwest corner and along the west line. The northeast quarter has an altitude of from 8,000 to 9,000 feet, and comprises steep, rocky ridges and dome-like hillocks more or less isolated by the interposition of ravines and glacial cirques. The upper portion of Clark Fork and the Broadwater cut the township from northwest to southeast.

Mining.—The southwest quarter of the township is mineral [illegible] it many claims, as yet chiefly prospects, have been located. It forms part of [illegible] Cooke City district.

Minerals.—Gold, silver, copper, lead.

Soil.—Gravelly loam, mostly thin and stony.

Agricultural adaptability.—None of the lands in the township are agricultural in character.

Grazing capacity.—The township contains many marshy glades along its streams and tarns; large areas of the northern portions are situated at or above timber line and present grass- or sedge-covered slopes. These tracts are suitable for pasturage, but are not utilized.

Drainage conditions.—The outflow from this township is very large and continuous. The chief water heads of Clark Fork rise in it; of these there are two, the main Clark Fork and the Broadwater. The former is a small stream 12 to 15 feet wide and 10 to 18 inches deep at medium stage; it flows in a wide canyon which in the southeast corner of the township ends in a broad flat. The Broadwater tributary is sunk in a deep, rocky canyon, the central portion of which has a remarkably level floor, the total fall in a distance of nearly 3 miles probably not exceeding 5 feet. The stream varies from 40 to 500 feet in width and from 15 inches to 8 feet in depth. Here and there it expands into lakelets, some of which are one mile long and nearly one-half mile wide. A short distance above its junction with Clark Fork, in the southeast corner of the township, the stream leaves its canyon through a narrow gorge, affording an excellent site for a storage dam. The hydrographic features of this township are of the greatest importance to the maintenance of the flow in Clark Fork.

Snow and rock slides.—In the high areas of the township avalanches are not uncommon.

Forest conditions.—The central areas of the township are covered with close-set stands of lodgepole pine and Engelmann spruce, mostly old growths. On the high-lying tracts the forest, subalpine in type, is low and scrubby, and is scattered around the margins of tarns and in the more sheltered localities in the hollows and ravines.

Cutting.—Near the junction of Clark Fork and its Broadwater tributary 60 per cent of the timber has been cut on 3,000 acres. The timber was used partly for fuel and mill timber and partly in the burning of charcoal for use of a former smelter in Cooke City.

Burns.—A few small burns occur in the southeast quarter of the tract.

Reproduction.—Abundant, except in the high subalpine areas. The young growth is composed of the same species and in nearly the same ratio as the old stands.

Undergrowth.—Light.

Litter.—Litter, composed of timber killed by overcrowding, is of moderate volume in the stands at the lower elevations. In the subalpine forest it is nearly lacking.

Humus.—Light, mostly totally lacking.

Classification of lands in T. 9 S., R. 15 E.

	Acres.
Forested	11,840
Nonforested	11,200
Badly burned	300
Logged	3,000
Agricultural	None.
Grazing	4,000
Bare rocks	4,700
Lakes and tarns	2,200

Total stand of timber in T. 9 S., R. 15 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	35,000,000	20,000,000	26,300,000
White-bark pine		3,000,000	3,000,000
Subalpine fir		7,000,000	7,000,000
Engelmann spruce	40,000,000	5,000,000	12,200,000
Total	75,000,000	35,000,000	48,500,000

Composition of forest in T. 9 S., R. 15 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	40
White-bark pine	6
Subalpine fir	10
Engelmann spruce	44

TOWNSHIP 9 SOUTH, RANGE 16 EAST.

Topography.—The southern and central areas comprise a tract of plateau-like country, with hillocks, irregular ridges and shallow depressions scattered over its surface. In the northern portion of the township the plateau rises in steep and deeply sculptured ridges which attain altitudes of nearly 12,000 feet.

Mining.—None.

Soil.—Rocky and gravelly. In the northern areas many of the higher slopes are entirely bare of soil, and present stretches of naked rock or slopes strewn with immense talus accumulations.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—Most of the tarns and lakelets in the region have small grassy glades fringing their margins, while the high-lying northern areas, where the soil cover is not lacking, bear thin swards of alpine sedges and grasses. The pasturage is on the whole, however, insignificant in extent.

Drainage conditions.—The region is dotted with a large number of lakes and tarns, all of great importance as constituting a series of natural reservoirs for Clark Fork. The run-off is steady and of considerable volume.

Snow and rock slides.—Not infrequent in the high and precipitous northern areas.

Towns and settlements.—The township is not inhabited.

Forest conditions.—The southern and central areas are covered with fairly uniform old-growth stands of lodgepole pine and Engelmann spruce. The northern areas bear thin stands of white-bark pine and spruce, or are wholly without forest cover. The timber in the southern and central areas is comparatively easy of access.

Cutting.—None.

Burns.—None.

Reproduction.—Good and abundant, except in the high northern areas. The prevailing species in the sapling and seedling growth is lodgepole pine, followed by Engelmann spruce.

Undergrowth.—The underbrush is sparse and scattering, particularly in the pure-growth lodgepole-pine stands, or where this species predominates.

Litter.—Abundant along the streams and margins of tarns, and in general where seepage prevails. It consists largely of spruce uprooted and overthrown by wind.

Humus.—There is commonly a thin layer of moss and decaying pine needles in the close-set stands, especially where the ground is swampy. In the more open forest on the uplands and at subalpine elevations the humus is lacking.

Classification of lands in T. 9 S., R. 16 E.

	Acres.
Forested	15,000
Nonforested	8,040
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	1,000
Bare rocks	3,040
Lakes, tarns, and streams	4,000

Total stand of timber in T. 9 S., R. 16 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine	20,000,000	22,000,000	25,600,000
White-bark pine		2,000,000	2,000,000
Subalpine fir		4,000,000	4,000,000
Engelmann spruce	17,000,000	10,000,000	13,060,000
Total	37,000,000	38,000,000	44,660,000

Composition of forest in T. 9 S., R. 16 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	60
White-bark pine	2
Subalpine fir	6
Engelmann spruce	32

TOWNSHIP 9 SOUTH, RANGE 17 EAST.

Topography.—The southeast quarter of the township comprises rolling tracts of plateau land—portions of the so-called Beartooth Plateau. The rest of the township consists of mountains 10,000 to 12,000 feet high and of immense rocky and bowlder-littered canyons. The entire region, with the exception of a few areas, is high and alpine in character.

Mining.—None.

Soil.—Thin, gravelly, bowlder strewn, except around the margins of tarns and lakelets, where loamy constituents are more or less mixed with the gravelly substrata.

Agricultural adaptability.—The township contains no arable land. Its altitude would in any event preclude agricultural operations.

Grazing capacity.—The region is covered with a low growth of alpine sedges or grass wherever any soil cover exists. In past years it has been extensively used for sheep pasture, but, with the exclusion of sheep from the reserve, cattle were the only kind of stock on the tract last year. About one-half shows marks of excessive sheeping in the partial destruction of the grass cover.

Drainage capacity.—The western and central areas abound in lakelets and tarns, springs, and small marshes, and form important natural reservoirs, in part to Rocky Fork Creek and in part to Clark Fork. The northern areas carry snow throughout the summer in many localities, and the total run-off from the tract is large and continuous.

Snow and rock slides.—Rock and snow slides are of frequent occurrence throughout the northern areas. Mud slips, carrying vast masses of bowlder talus and drift, are common around the higher-lying tarns and on many of the steeper slopes.

Forest conditions.—The township contains no forested areas. In the southern portions small copses and thin lines of white-bark pine and spruce, with an undergrowth of willows, border the tarns and rivulets.

Classification of lands in T. 9 S., R. 17 E.

Forested	[illegible]
Nonforested	[illegible]
Agricultural	None
Grazing	15,000
Bare rocks	5,500
Lakelets and tarns	2,540

Township 9 South, Range 18 East.

Topography.—This township is included in what is known as Beartooth Plateau, a rolling tract of country, situated mostly at elevations of 10,000 to 11,500 feet, on the east stretching into adjoining township, and on the west breaking off with vast cliffs and precipices to the depths of Rocky Fork Canyon. The summit of the plateau is intersected with combs, ridges of rock, and heaped-up masses of bowlders, while shallow draws, gullies, and ravines break the levels in various directions.

Mining.—None.

Soil.—Gravelly loam, with the surface in most localities strewn with bowlder drift.

Agricultural adaptability.—No portion of the township contains any arable land.

Grazing capacity.—With the exception of precipitous slopes, mostly confined to the western areas, the entire tract is covered with a close turf or sward of alpine sedges, grasses, and low herbaceous plants of other orders. The tract has heretofore been excessively sheeped, and much of the former grass growth has been eaten out.

Drainage conditions.—The run-off from the tract is comparatively small. There are, however, numerous small springs and points of marshy seepage, with occasionally a group of tarns, while many of the shallow draws hold banks of snow throughout the summer.

Snow and rock slides.—Avalanches of snow and rock are not infrequent in the western areas, falling from the summit of the plateau to the bottom of Rocky Fork Canyon. Mud slips, sometimes nearly a half mile in length, exist in many of the shallow draws on the summit of the plateau, and are slowly sliding toward its breaks.

Towns and settlements.—The district is uninhabited.

Forest conditions.—The forested areas are small. They dot the plateau in various directions up to altitudes of 10,000 feet, and line the canyons in the southern portions of the township and the bottoms in Rocky Fork Canyon with sparse and thin groups of trees and copses. Most of the forest has a precarious existence, owing to its position at or near timber line. It consists wholly of the subalpine type, chiefly white-bark pine and Engelmann spruce. The trees are low, stunted, and scrubby, and are valuable only for fuel.

Cutting.—None.

Burns.—None.

Reproduction.—Young growth is sparse, barely sufficient to insure the continuance of the present thin stockage of the stands.

Undergrowth.—In the timber the underbrush consists of scattered willows. The springy and swampy areas on the summit of the plateau at alpine elevations are invariably covered with a dense matting of willows wherever sheep have not destroyed the growth by browsing and trampling.

Litter.—None.

Humus.—None.

Classification of lands in T. 9 S., R. 18 E.

	Acres.
Forested	1,800
Nonforested	21,240
Badly burned	None.
Logged	None.
Agricultural	None.
Grazing	17,500
Bare rocks	3,000
Lakelets and tarns	740

Total stand of timber in T. 9 S., R. 18 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
White-bark pine		650,000	650,000
Subalpine fir		200,000	200,000
Engelmann spruce	1,000,000	550,000	730,000
Total	1,000,000	1,400,000	1,580,000

Composition of forest in T. 9 S., R. 18 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
White-bark pine	15
Subalpine fir	25
Engelmann spruce	60

TOWNSHIP 9 SOUTH, RANGE 19 EAST.

Topography.—The township consists of a plateau-like area—a portion of Beartooth Plateau—varying in altitude from 10,000 to 11,000 feet. The surface is rolling and intersected with low combs, ridges, and shallow canyons, the latter of which develop immense rocky gorges along the east and west lines of the township.

Mining.—None.

Soil.—Gravelly loam, the surface stony and bowlder strewn.

Agricultural adaptability.—Owing to the high altitude of all portions of the district none are cultivable.

Grazing capacity.—With the exception of 3,000 acres the township consists of open land, covered with alpine grasses and sedges. The tract has been excessively sheeped during periods covering many years up to the past summer of 1908, and the better part of the herbage has been eaten and trampled out.

Drainage capacity.—Only a very small outflow originates in the township. Springs, places of seepage, and one or two tarns occur on the summit of the plateau.

Snow and rock slides.—Apparently infrequent.

Towns and settlements.—The township is not inhabited.

Forest conditions.—The forest is limited to a few small stands of subalpine type occurring in the southern areas of the district. It is inaccessible except for local use, and has chiefly a fuel value.

Cutting.—None.

Burns.—A small tract comprising 100 acres has been burned over.

Reproduction.—Reproduction is exceedingly scanty. Apparently the forest occupies less ground now than in former times, owing probably to repeated burnings of the grassy tracts and destruction of the forest fringing them, and subsequent lack of reforestation.

Undergrowth.—Chiefly low-growing willows.

Litter.—Very light.

Humus.—None.

Classification of lands in T. 9 S., R. 19 E.

	Acres.
Forested	2,500
Nonforested	20,540
Badly burned	100
Logged	None.
Agricultural	None.
Grazing	20,000
Bare rocks	440

Total stand of timber in T. 9 S., R. 19 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M	*Cubic feet.*	*Cubic feet.*
Lodgepole pine		200,000	200,000
White-bark pine		350,000	350,000
Subalpine fir		800,000	800,000
Engelmann spruce	2,000,000	1,000,000	1,360,000
Total	2,000,000	2,350,000	2,710,000

Composition of forest in T. 9 S., R. 19 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	4
White-bark pine	26
Subalpine fir	40
Engelmann spruce	30

TOWNSHIP 9 SOUTH, RANGE 20 EAST.

Topography.—The western and central areas of the township consist of a plateau-like region varying in elevation from 10,000 to nearly 11,000 feet. The surface is broken into long, low swells, short combs of rock 200 to 400 feet high, broad levels, and intersecting shallow draws or ravines that form the water heads of various creeks. The eastern areas consist of excessively steep and precipitous breaks to the levels which border Clark Fork, forming a front to the plateau nearly 5,000 feet in height, and of a narrow strip of level or rolling desert land fringing the foot of the plateau.

Mining.—None.

Soil.—The soil is gravelly, except along the foot of the plateau, where it is more or less loamy. The summit of the plateau is mostly bowlder strewn.

Agricultural adaptability.—The plateau areas are situated far above the altitudinal limits for agriculture; the desert strip at the eastern foot of the plateau is without water for irrigation.

Grazing capacity.—The summit of the plateau and the level areas at its foot are grass or sedge covered. Up to the present the tracts have been closely and excessively sheeped and have therefore only a very low grazing value.

Drainage conditions.—The run-off is small. Springs and points of seepage occur in many localities on the summit of the plateau, but the small creeks to which they give rise are mostly dry runs before they reach the levels at the foot of the plateau.

Snow and rock slides.—Frequent along the steep declivities of the eastern front of the plateau.

Towns and settlements.—None.

Forest conditions.—The forest is thin and scattered. It consists wholly of the subalpine type, white-bark pine and Engelmann spruce being the dominant species. It is chiefly an old growth, and is mostly confined to the slopes and breaks of the eastern front of the plateau. Its value is principally for fuel and the stability it imparts to the loose talus slopes where it grows. Most of it is inaccessible. The summit of the plateau lies for the most part above timber line.

Cutting.—None.

Burns.—A tract in the east-central area, amounting to 500 acres, has been burned over within the last six or eight years.

Reproduction.—Young and sapling growth is scanty throughout the burned-over tracts are reforesting tardily.

Undergrowth.—Sparce throughout; mostly willows and *Shepherdia.*

Litter.—In the burned-over districts there are moderate quantities of dead and down timber. Elsewhere the litter is light or lacking.

Humus.—None.

Classification of lands in T. 9 S., R. 20 E.

	Acres.
Forested	3,880
Nonforested	19,160
Badly burned	500
Logged	None.
Agricultural	None.
Grazing	18,000
Bare rocks	660

Total stand of timber in T. 9 S., R. 20 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Lodgepole pine		1,000,000	1,000,000
White-bark pine		2,000,000	2,000,000
Subalpine fir		1,000,000	1,000,000
Engelmann spruce	1,500,000	2,000,000	2,270,000
Total	1,500,000	6,000,000	6,270,000

Composition of forest in T. 9 S., R. 20 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	30
White-bark pine	35
Subalpine fir	10
Engelmann spruce	25

TOWNSHIPS ADJOINING THE ABSAROKA DIVISION.

The following-described tracts, to wit, T. 7 S., R. 19 E.; T. 7 S., R. 20 E.; T. 8 S., R. 20 E., adjoin the Absaroka division on the east. As they are partly forested from the termination of the timbered areas stretching west, and may in the future be included in the forest reserve, the estimates and detailed descriptions have been extended to cover them.

Township 7 South, Range 19 East.

Topography.—The central and southern areas comprise steep, rocky spurs, rising to form divides between West Rocky Fork and the Red Lodge Creek drainage and reaching elevations of 9,800 feet. The northern portion of the township consists of rolling foothill areas intersected by many shallow ravines and gulches.

Mining.—None.

Agricultural adaptability.—The mountainous areas are too rough for tillage, and the foothill region is so stony and so cut up with ravines and gulches that farming is practically impossible.

Forest conditions.—The forest consists of thin, poorly stocked stands of lodgepole pine and red fir, and is confined to the mountain areas and to a narrow strip of adjoining foothill region. Small stands of very close-set aspen and lodgepole pine push out from the foothills into the agricultural areas along the various ravines and points of seepage. Most of the forest is in the pole stage, 25 to 40 years old.

Cutting.—Forty per cent of the stands have been cut over, the cut varying from 50 per cent to total. The timber has been used for props in the coal mines at Red Lodge, and there and at other localities for fencing and fuel.

Burns.—Fires within the past ten years have destroyed the timber on tracts aggregating 1,200 acres.

Reproduction.—Very scanty on the areas burned over within recent years; abundant elsewhere and composed mostly of lodgepole pine and aspen.

Undergrowth.—Light or none in the green forest. On the burned-over ground *Ceanothus velutinus* is springing up in dense masses.

Litter.—A small quantity of dead and down pole timber remains on the burns. Most of the fire-killed timber was long ago cut off and converted into fencing, mine props, and fuel. There is not much litter in the green stands.

Humus.—None.

Classification of lands in T. 7 S., R. 20 E.

	Acres.
Forested	3,830
Nonforested	19,200
Badly burned	1,200
Logged	2,000
Agricultural-grazing	18,000

Total stand of timber (pole and fuel) in T. 7 S., R. 20 E.

	Cubic feet.
Limber pine, lodgepole pine, red fir	750,000

Composition of forest in T. 7 S., R. 20 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	3
Lodgepole pine	75
Red fir	5
Aspen and cottonwood	17

TOWNSHIP 8 SOUTH, RANGE 20 EAST.

Topography.—The western portion of the township is a part of Beartooth Plateau, a level and rolling tract of alpine and subalpine country rising to altitudes of 10,000 and 11,000 feet. The central areas comprise a series of cliffs and

Total stand of timber (pole and fuel), in T. 7 S., R. 19 E.

	Cubic feet.
Lodgepole pine	1,000,000
White-bark pine	....
Subalpine fir	900,000
Engelmann spruce	....
Total	1,900,000

Composition of forest in T. 7 S., R. 19 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	82
White-bark pine	8
Subalpine fir	4
Engelmann spruce	3
Aspen and cottonwood	3

Of the very young growth, comprising trees 2 inches to 2½ inches in basal diameter, aspen forms 20 per cent.

TOWNSHIP 7 SOUTH, RANGE 20 EAST.

Topography.—With the exception of six sections in the southwest portion the township consists of level and rolling tracts of agricultural and grazing lands. The mountain areas comprise low, broken terminations of spurs stretching eastward from high divides in the township adjoining on the west, and vary in altitude from 1,000 to 1,500 feet above the adjacent levels on the east.

Mining.—No ore deposits are known to occur. In several places in the western portion of the township limestone is quarried and burned to quicklime. Coal is mined at Red Lodge, in the eastern areas.

Soil.—Deep loam in the valley bottoms, gravelly and thin on most of the uplands; mixed with a great deal of bowlder drift along the west line.

Agricultural adaptability.—The lands are agricultural in character where the soil is not too stony nor the contours too steep, and where water for irrigation is obtainable. The mountain areas in the western portion of the district are not cultivable.

Grazing capacity.—The level and rolling tracts where not tillable are used as range ground.

Drainage conditions.—There is only an insignificant volume of run-off originating in the township. It is all comprised in the discharge issuing from a series of small springs along the base of the mountains in the district.

Snow and rock slides.—None.

Towns and settlements.—The eastern and central areas contain numerous farmsteads on the agricultural lands. The city of Red Lodge is situated in the southeast quarter of the township.

Classification of land in T. 8 S., R. 20 E.

	Acres.
Forested	7,040
Nonforested	16,000
Badly burned	1,800
Logged (culled)	800
Agricultural	500
Grazing	12,800
Bare rocks	900

Total stand of timber (pole and fuel) in T. 8 S., R. 20 E.

	Cubic feet.
Lumber pine	20,000
Lodgepole pine	3,500,000
White-bark pine	800,000
Red fir	150,000
Subalpine fir	900,000
Engelmann spruce	800,000
Total	6,170,000

Composition of forest in T. 8 S., R. 20 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lumber pine	0.1
Lodgepole pine	35
White-bark pine	25
Red fir	.4
Subalpine fir	10.5
Engelmann spruce	29

LIVINGSTON AND BIG TIMBER QUADRANGLES.

The Absaroka portion of the Yellowstone Forest Reserve, in Montana, is represented in part on the Livingston and Big Timber atlas sheets of the topographic map of the United States published by the United States Geological Survey. The Livingston quadrangle contains 30 per cent and the Big Timber quadrangle 13.5 per cent of the area discussed.

The present examination was made primarily to classify the lands and estimate the timber within the boundaries of the reserve, but the land classification and timber estimates have been made for tracts beyond the reserve boundaries in order to include all of the Livingston and Big Timber quadrangles, and the following general description of the different classes of lands has been added to the re[illegible] accounts of sylvicultural conditions in the reserve apply equally to the [illegible] areas in these quadrangles beyond its boundaries.

LIVINGSTON QUADRANGLE.

LOCATION, EXTENT, AND CLASSIFICATION OF LANDS.

The Livingston quadrangle is situated in Montana between 45° and 46° north latitude and between 110° and 111° west longitude, comprising an area of 2,146,664 acres. The lands consist of forest, woodland, and nontimbered tracts, with the acreage of the several classes shown in appended table:

Classification of lands in the Livingston quadrangle, Montana.

	Acres.
Forested	886, 120
Woodland	54, 000
Nontimbered	1, 206, 544
Total	2, 146, 664

The nontimbered lands comprise tracts of great diversity in their topographic and physical features, owing to the altitudinal differences in their position. They are here divided into four general classes, as shown in the following table:

Classification of nontimbered lands in the Livingston quadrangle, Montana.

	Acres.
Agricultural	256, 356
Grazing	712, 115
Bare rocks and high alpine	227, 433
Lakes and tarns	10, 640
Total	1, 206, 544

TOPOGRAPHIC FEATURES.

The quadrangle comprises two marked divisions—a southern, made up almost wholly of rough mountain areas, and a northern, consisting of rolling, semiarid plains, hemmed in by a stretch of mountain rampart along the west side and rising into a small tract of rugged and rocky heights in the north-central areas.

The high relief in the southern portions of the quadrangle is formed by portions of the Gallatin Range and by the north half of the Absaroka Range, both of them eastern extensions of the Rockies. The low relief, aside from the canyons and short valleys in the interior of the mountain regions, is formed by the valley of Yellowstone River, bisecting the district from south to north and separating the Gallatin and Absaroka ranges by a comparatively broad valley.

The portion of the Gallatin Range within the quadrangle consists, in its northern part, of a narrow, rocky crest, fronting rather abruptly on the valley of Yellowstone River and sending out short, steep spurs. With a westerly trend the crest line of the range gradually passes beyond the limits of the quadrangle until, in the southwest corner, the range is represented only by eastern terminations of long and broken spurs. The canyon system consists of narrow, short troughs with rapid descents. The mean elevation of the range, including its immediate slopes, is 8,200 feet, approximately; isolated knobs on a few of the higher ridges attaining altitudes of 10,000 feet.

The Absaroka Range consists of a huge uplift of granite flanked by limestones and outflows of Tertiary lavas. It is a very rough and rugged region, deeply and extensively sculptured by the erosive power of the vast glacier field, which in times past covered its entire area. The tract is a succession of deep, cliff-lined canyons and tortuous ridges, the larger with a generally north-south trend. The crests of the ridges are mostly narrow and sharp, presenting vast masses of cracked and crumbling overhang. Occasionally they widen and are studded with peaks and pinnacles, or become broader and expand into plateau-like tracts. Their slopes, as they front on the valleys and canyons, are remarkably steep, frequently rising in scarps and precipices 1,000 to 2,000 feet in height. Vast quantities of talus extend up the slopes and deep deposits of bowlder and gravel drift litter the canyon bottoms. The mean elevation of the tract outside the immediate canyon floors is estimated at 8,500 feet. Here and there peaks reach altitudes of 11,000 to 12,000 feet; but none of the tracts reach the line of perpetual snow on all slopes.

The high relief of the north half of the quadrangle is formed by a section of the Bridger Range and the southern termination of the Crazy Mountains. The Bridger Range, a northward continuation of the Gallatin Range, consists of a narrow, serrated, extremely rocky ridge, rising sharply from the levels of the surrounding tableland, buttressed by numerous short and steep spurs and indented by a multitude of rifts, ravines, and gorge-like canyons. The average elevation is about 7,800 feet, while points along the crest attain altitudes of 9,100 feet. The section of Crazy Mountains in the north-central regions of the district covers a tract of approximately 47,000 acres, and consists of steep slopes rising directly and continuously from the plains level to altitudes of 10,400 feet.

The low areas of the quadrangle consist of a rolling, timberless plain, rising in more or less broken and continuous terraces to intersecting broad swells and ridges, falling away in long, gentle slopes to the valleys of Yellowstone and Shields rivers, which border and bisect the district, or knobbed with lines of rocky buttes and furrowed by shallow canyons and depressions.

The lowest depressions in the quadrangle are along Shields and Yellowstone rivers. The former bisects the quadrangle from north to south; the latter forms in part a dividing line between the mountainous southern areas and the plains districts of the northern part of the quadrangle. Both streams flow in broad valleys lined with low bluffs, which alternately approach and recede from the stream banks. The mean elevation of the plains regions is 5,200 feet; that of the Yellowstone flood valley, 4,200 feet.

DRAINAGE CONDITIONS.

Most of the quadrangle lies within the Yellowstone drainage, small tracts only, situated on the western slopes of the Bridger and Gallatin ranges, draining into the Missouri through other channels than the Yellowstone. The run-off is large, most of it being supplied from the 38 per cent of its area covered with the spurs, peaks, and canyons of the range. This tract, the altitude of which insures an abundance of rainfall, is, in fact, an immense natural reservoir, and as such of the greatest importance to the central regions of the Yellowstone drainage. Next in importance is the Shields River drainage, but outside its freshet period in early summer the volume carried by the stream is small. The lesser creeks and streams originating in the Gallatin and Bridger ranges are small and variable in their flow. A large number of ravines and canyons head in the small tract of the Crazy Mountains in the north-central part of the district, but the run-off carried by them is comparatively insignificant. The minor creeks, which head in the rolling areas of the plains, carry water during the spring break-up, but are dry in the summer and fall.

AGRICULTURAL LANDS.

The cultivable lands, comprising nearly 12 per cent of the quadrangle, border the streams either directly in the flood valleys or on the lower terraces not far from the main stream or its tributaries. The largest single area of cultivable land is situated within the Shields River drainage. Irrigation is required everywhere for the successful cultivation of crops. Doubtless much of the land now utilized as cattle and sheep ranges can be reclaimed by means of high-line ditches, but the generally high and rolling character of the plains region, and the lack of large volumes of water, except in the low-lying Yellowstone River, will probably preclude any extensive scheme of reclamation of lands remote from the flood valleys of the streams. The agricultural areas in the mountain districts consist of small, level pieces of bench or semimarsh land in the bottoms of the larger canyons below the 6,000-foot contour, the total comprising less than 15,000 acres. The soil on the lowest terraces in the valleys is usually rich and deep. A large amount of land situated on the upper terraces and on the swells away from the streams is covered with bowlder and gravel drift of glacial origin, and is worthless for agricultural pursuits. Grain, hay, small quantities of apples, and the ordinary northern bush fruits are produced.

GRAZING LANDS.

The grazing lands in the quadrangle comprise a trifle more than 33 per cent of its area. They consist in part of the rolling plains region in the northern part of district, and in part of tracts in the mountain region situated at or above timber line, while a large remainder is made up of fire glades, mostly in the subalpine forest, which, from a variety of causes, have never restocked. The grazing areas in the strictly alpine regions are confined to the high tracts above the 9,200-foot contour in the Absaroka ranges. The fire glades in the subalpine forest occur in all the mountain areas.

Originally the plains were well stocked with a luxurious growth of bunch grasses. They were easy of access, sufficiently well watered for the stockman's needs, and in every way suitable for range purposes, but they have been excessively pastured, and their present grazing value is exceedingly low where not inclosed. The inclosed areas show a decided betterment, and with freedom for a few years from excessive pasturing of both cattle and sheep, would show a great improvement. As it now stands there is a small amount of grass early in the summer. In a few weeks cattle and sheep have exhausted it, and during the greater portion of the year the tracts afford only the scantiest grazing or none at all.

The alpine areas, mostly located above timber line, are closely covered with a tough sward of low alpine and subalpine grasses and sedges. All are more or less difficult of access, which fact, together with the short season, has prevented any extensive use being made of them. Most of the lands of this character in these ranges appear never to have been pastured by any domestic animals except by horses belonging to the prospectors of the region.

The subalpine areas have been grazed to a limited extent, mostly on the Bridger and Gallatin ranges, because they front directly on the plains and are therefore easy of access, while the subalpine areas in the adjoining ranges occur mostly in the interior. This class of grazing lands is as yet in a fair condition.

BARE ROCK AND HIGH ALPINE AREAS.

Extensive tracts of this character occur throughout all the mountain areas and in the aggregate they comprise nearly 10 per cent of the quadrangle. The upper slopes of Bridger Range are mostly bare rock, the crests and higher slopes contributing the larger proportion. These localities are often so steep that no soil can adhere or find lodgment, and in consequence vegetation is lacking. The alpine regions comprise snow fields on the northern slopes, sharp steep peaks, and mud slides formed of talus débris.

LAKES AND TARNS.

The lakes and tarns cover 0.5 per cent of the quadrangle. Their origin is due to the effects of glacial erosion. Most of them lie in hollows and in glacial cirques, on the summit of the alpine plateau areas and near the heads of the [illegible] streams. In a few cases they are held back by rocky barriers across the outlets, [illegible] majority of cases by morainic accumulations. All of them are small in [illegible] and of shallow depth, but nevertheless form series of natural reservoirs of [illegible] importance in the regimen of the streams which head in them.

WOODLANDS.

The woodlands form 2.55 per cent of the quadrangle. They consist of scattered, sparsely timbered tracts in the foothills flanking the Bridger and Absaroka ranges, and of thin lines of trees fringing the larger streams. The uplands areas are stocked with limber pine, yellow pine, red fir, and a little lodgepole pine. The timber in these stands is low, stunted, and of inferior quality throughout, suitable only for fuel and fencing material. Along the streams the stands are set more closely than on the uplands. They consist of different proportions of aspen, cottonwood, and aborescent willows. As protection against wash and wear of the alluvial stream banks and terraces, and as supplying considerable quantities of fuel, they are of value.

The woodlands in the foothill region have a low restockage ratio. Climatic conditions—semiaridity—prevent abundant seed reproduction, as the grassy sward which covers the ground obstructs the proper inhumation of the seeds and their subsequent germination. Small quantities of underbrush are present, consisting mostly of sagebrush and shrubby cinquefoil.

The woodlands that border the streams restock rapidly. The cottonwoods and aspens are abundant and steady seed producers. Much dense undergrowth, formed by a mass of interlacing willows and wild-rose brush, is nearly always present, except in very old-growth cottonwood stands, where commonly a grassy sward forms the ground cover.

The average yield of timber in the woodlands of the foothill region is between 800 and 900 cubic feet per acre; in the cottonwood stands fringing the streams the yield rises to 900 or 1,000 cubic feet. Circumscribed localities occasionally yield twice the amount stated, but stands of that density are rare owing to long-continued cutting of the best and most easily reached blocks of timber.

FOREST.

The forested areas of the quadrangle comprise about 40 per cent. They lie chiefly between the 6,000 and the 9,500 foot contours, and hence belong to the mountain regions of the district. In some localities, particularly in the canyon bottoms in the interior portions of Absaroka Range, the lower limit for the forest falls to the 5,300-foot level, while in the foothills of Gallatin Range fronting on the Yellowstone Valley the lower limit stops at the 7,000-foot level in some localities.

The forest is composed of limber pine, lodgepole pine, white pine, white-bark pine, red fir, subalpine fir, Engelmann spruce, aspen, cottonwood, various species of arborescent willows, thorn, wild cherry, and serviceberry. The coniferous species form the principal part of the growth; the percentage contributed by the broad-leaved species is insignificant.

The forest appears in three general zones or strata, which blend where they meet and are not closely differentiated, though fairly well marked in their central areas. The upper zone, stretching to timber line at 9,500 to 9,800 feet, is composed of Engelmann spruce, subalpine fir, and white-bark pine, with the addition of lodgepole pine in varying proportions at the lower limits. The spruce forms the largest percentage of the zone, followed by white-bark pine and subalpine fir. Occasionally this arrangement is reversed and white-bark pine takes the lead or even subalpine fir may hold the dominant place; but in stands where a normal ratio has been established spruce always leads. The stands of this zone are open and scattered at their upper limits and are often very compact and densely stocked at their lowest. The open stands are set in grassy tracts or fire glades which have only partly restocked since they were burned over. The subalpine forest contains little mill timber. Its chief value lies in the stability it imparts to the upper slopes and in the volume of fuel and mine timber it is capable of supplying.

The central zone consists of well-stocked stands composed of red fir, lodgepole pine, and Engelmann spruce, lodgepole pine constituting the dominant species. In some localities at the lower levels of the zone red fir becomes the chief species, and occasionally along the stream margins in the lowest canyons Engelmann spruce predominates. The bulk of the forest in the quadrangle occurs in this zone, both the saw timber and the pole and fuel size.

The lowest zone in the series borders the plains, or the woodlands when woodlands are present. The forest in this zone commonly is open and more or less broken, its heaviest stands occurring on the northern slopes of ridges and canyons where the semiarid conditions of the nearby plains are less marked. It is composed of red fir, yellow pine, limber pine, and small proportions of Engelmann spruce along the streams. Red fir is always the dominant species in this zone, the other coniferous species constituting only a small percentage.

The proportion of the coniferous species in the forests of the quadrangle is shown in appended table.

Composition of the forest in the Livingston quadrangle, Montana, including trees of all species with basal diameters of 4 inches and upward.

	Per cent.
Limber pine	3
Lodgepole pine	42
White pine	less than .1
White-bark pine	5
Yellow pine	[illegible]
Red fir	[illegible]
Subalpine fir	[illegible]
Engelmann spruce	[illegible]
Aspen and cottonwood	[illegible]

The supply of mill timber in the forest is small. Most of the stands are composed of pole growths less than 130 years old, at which age the lodgepole pine, the chief timber tree, has not attained sufficient diametrical dimensions to become available for mill purposes, except in very favorable localities. Most of the timber is fit only for fuel, fencing, and other purposes where pole timber can be utilized. The mill timber throughout is of 3-inch grade, and on an average will not square over 10.25 inches. Most of the timber in the quadrangle grows in localities difficult of access; not over 10 per cent is so situated that it can be reached without entailing expenses almost equal to the present value of the product.

The amount of timber standing in the district is shown in the appended table:

Total stand of timber in the Livingston quadrangle, Montana.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	5,000,000	16,380,000	17,280,000
Lodgepole pine	427,000,000	636,100,000	712,960,000
White pine	3,500,000	300,000	930,000
White-bark pine	15,050,000	77,050,000	79,759,000
Yellow pine	3,000,000	5,000,000	5,540,000
Red fir	177,100,000	220,350,000	252,228,000
Subalpine fir	3,000,000	93,200,000	93,740,000
Engelmann spruce	306,000,000	221,450,000	276,530,000
Aspen and cottonwood	....	2,000,000	2,000,000
Total	939,650,000	1,271,830,000	1,440,967,000

The tracts more or less logged and culled comprise in the aggregate 85,000 acres. They are situated on the eastern slopes of Gallatin and Bridger ranges, in the foothills in the Boulder River drainage, in the eastern and southern edges of the Absaroka ranges, and on the lower slopes of Crazy Mountains. Most of the cutting has been for fuel and fencing material. Lesser amounts have been taken to furnish ties for railroad construction and for props in the coal mines on the eastern slopes of Gallatin Range.

Forest reproduction is good throughout the middle zone and in the higher portions of the lowest of the timber zones. It is deficient in the subalpine forest; that is, the restockage is not sufficient to reoccupy the areas which in the course of centuries have been denuded by fire. Lodgepole pine is the dominant species in the reforestations in the young growth and in the older stands at middle elevations.

Extensive forest fires have ravaged the timber within recent years. In the aggregate 90,000 acres have been laid waste. The fires have been more extensive in the Absaroka Range than elsewhere, and in all places where they have run through the stands complete destruction has been the result. The region has always been subject to widespread and destructive forest fires, as proved by the age of the timber.

BIG TIMBER QUADRANGLE.

LOCATION, EXTENT, AND CLASSIFICATION OF LANDS.

The region embraced in the Big Timber quadrangle, Montana, is situated between 45° 30′ and 46° north latitude and between 109° 30′ and 110° west longitude, and contains an area of 534,283 acres. Forest, woodland, agricultural, and grazing areas are represented within the quadrangle, the acreage of the different classes of land being shown in subjoined table.

Classifiation of lands in the Big Timber quadrangle, Montana.

	Acres.
Forested	27,000
Woodland	206,000
Nontimbered	301,283
Total	534,283

The nontimbered lands, excluding the areas of bare rock, differ but little in their general features, except as regards their water supply and dependent irrigation facilities. They are classified as follows:

Classification of nontimbered lands in the Big Timber quadrangle, Montana.

	Acres.
Agricultural	34,300
Grazing	253,283
Bare rocks	13,700
Total	301,283

TOPOGRAPHIC FEATURES.

Excepting the southwest quarter, the quadrangle is a rolling plateau area cut by many shallow, more or less rocky, and in some cases gorge-like, canyons. Broad swells and low, rocky, irregular ridges separate the different ravines and canyons. The lowest altitude is in the valley of the Yellowstone, which bisects the quadrangle from west to east. The valley varies from 1 to 3 miles in width, and is made up of two to three low terraces, bordered by low bluffs of sedimentary rocks, which present sharp scarps to the river front and alternately approach and recede from the immediate river except in the northeast quarter of the quadrangle, where they are close to the stream for a distance of 18 miles and display a steep, solid front of [illegible] to 400 feet in height.

The southwest quarter of the quadrangle consists of mountain areas formed by the terminations of northward-projecting spurs from the Crazy Mountains [illegible]

known as "moss," scattered patches of *Chrysothamnus* and *Artemisia* shrubs, and cacti. Where not so closely grazed a thin growth of grass comes up in the spring and supplies pasturage for a month or two, after which nothing remains but close stubble. The semiarid climate naturally brings about a low recuperative power in the gramineous vegetation, and, with the excessive pasturing to which it long has been subjected, its destruction has, from the first, been a logical result.

Where the grassy turf has been at all extensive and completely destroyed there has been gullying and denudation of the surface soil. Everywhere the "ditch," as the lowest central depression in the canyon bottoms is aptly called, shows encroachment on adjoining bench land or slope. It is clear that these waterways carry larger volumes of water now during spring freshets than they formerly did, and that their gullying power has correspondingly increased. The denudation of the surface soil on the badly sheeped lands is especially marked on tracts situated in the lower Deer and Work creeks drainage. Here the gullying of the soft soil on the uplands, a sort of gumbo, is rapidly creating "bad lands." The result of the destruction of the grassy turf on these plains is the same as from the destruction of forest covers on mountain slopes—accelerated run-off, extensive and rapid gullying, and removal of the soil cover.

WOODLANDS.

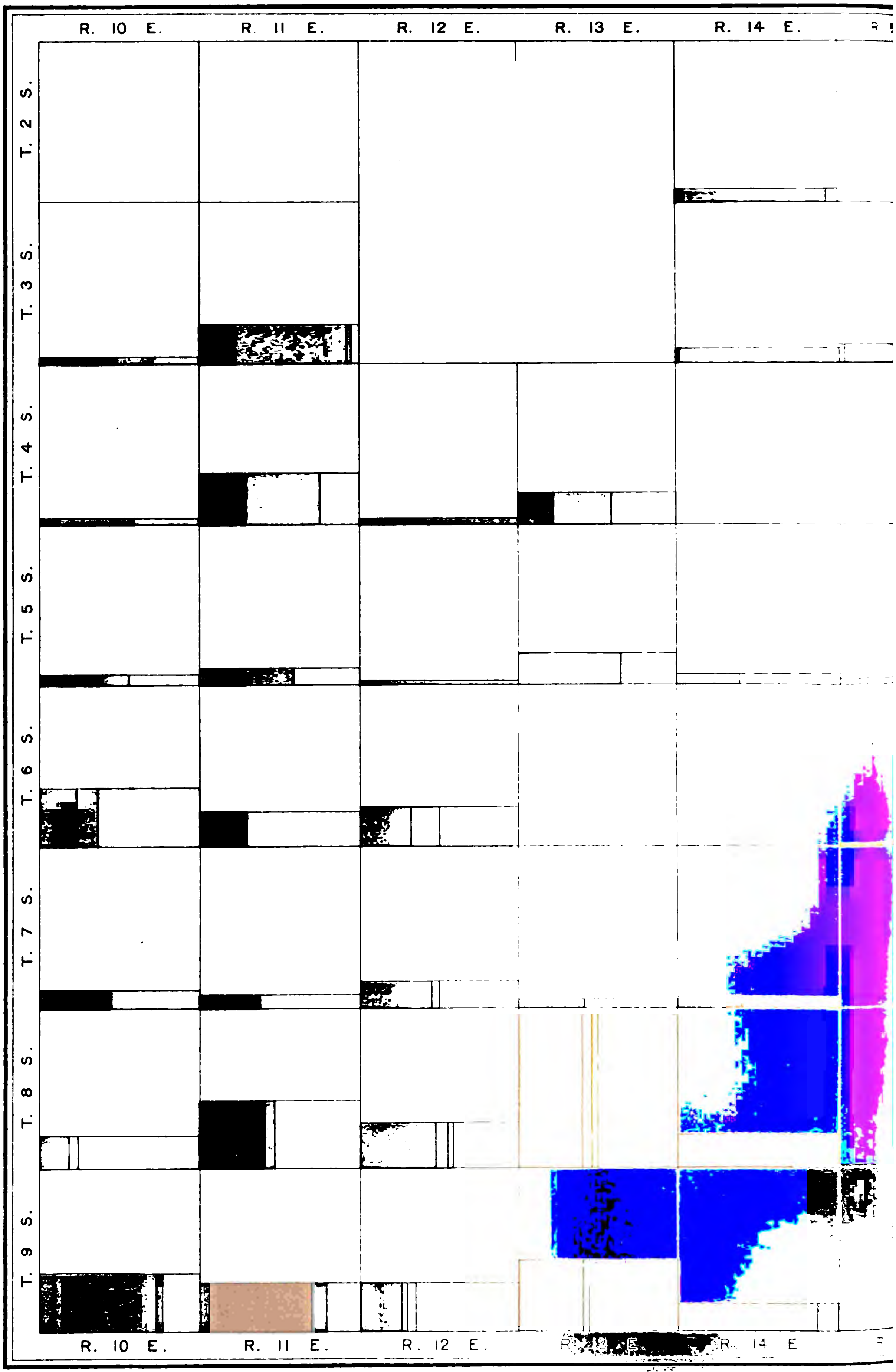
A trifle more than 38 per cent of the quadrangle may be classed as woodland. The largest proportion is situated in the northeast quarter on a tract 500 to 600 feet above the average level of the nontimbered lands. Smaller tracts occur in the southwest quarter, where they occupy a foothill region having an altitude of from 5,500 to 6,000 feet. Lesser areas fringe the larger streams in more or less continuous lines.

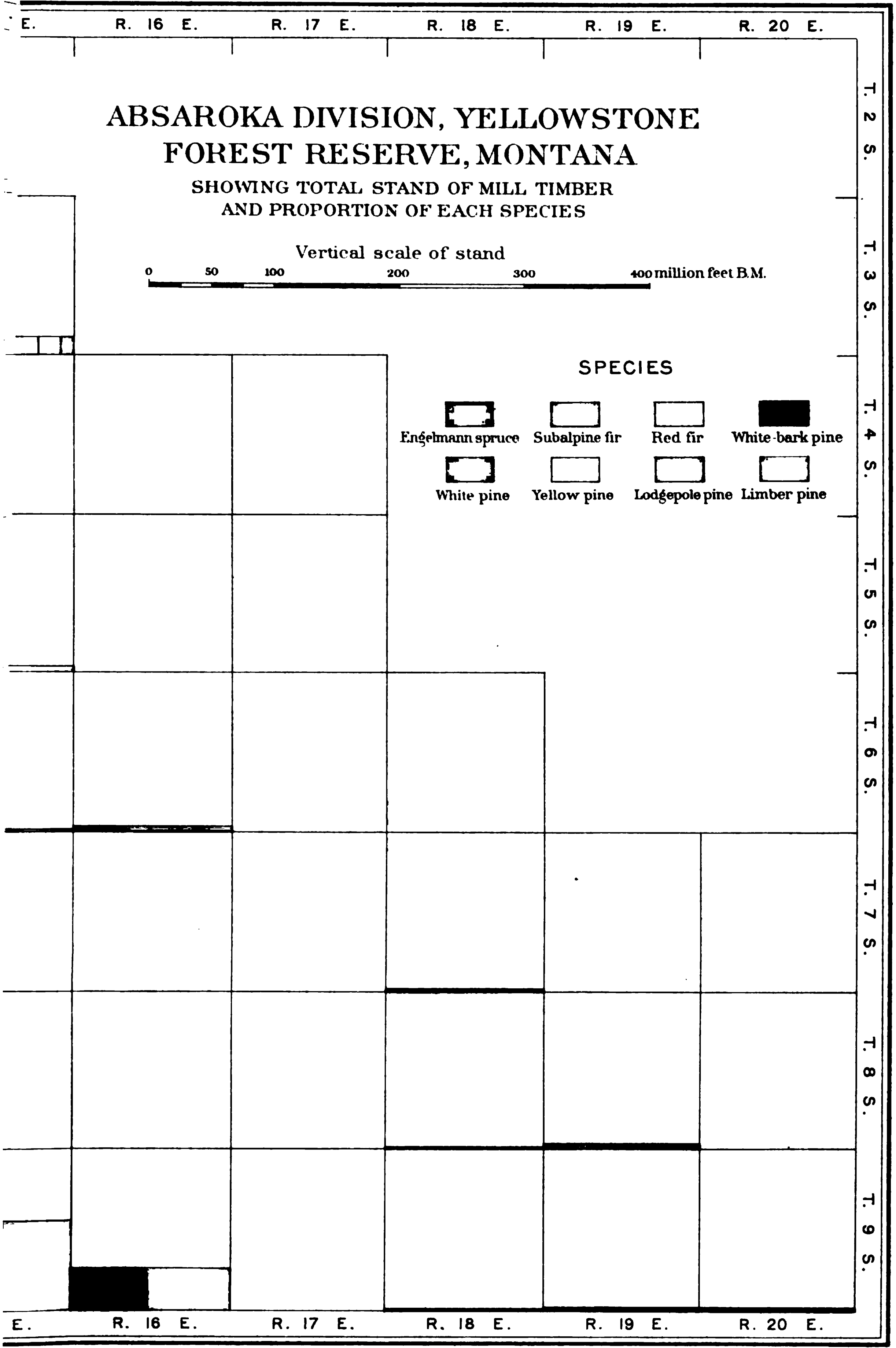
The woodlands are generally lightly stocked with timber. Limber pine, yellow pine, red fir, and juniper, of the coniferous species, and aspen and cottonwood, of the broad-leaved trees, are represented in the stockage.

The lightly timbered conditions of these tracts are due to the many visitations of fire which they have experienced during centuries, and to a naturally scanty and defective seed production due to the arid climate. The stands are capable of closer stockage, but to insure this result absolute freedom from fire and grazing is necessary. Most of the timber has only a pole and fuel value. Less than 10 per cent is mill timber, with only a 3-inch class value. The average yield of timber is 850 cubic feet per acre.

The fringes of woodland along the streams are valuable only for fuel and fencing material and, most of all, for the cohesion and waste-resisting power their widely spreading roots impart to the soft alluvium of the stream banks.

U.S. GEOLOGICAL SURVEY





ABSAROKA DIVISION, YELLOWSTONE FOREST RESERVE, MONTANA

SHOWING TOTAL STAND OF MILL TIMBER AND PROPORTION OF EACH SPECIES

JULIUS BIEN & CO. LITH. N.Y.

The composition of the woodland stands is as follows:

Composition of the stands of timber in the woodlands of the Big Timber quadrangle, Montana.

	Per cent.
Limber pine	30
Yellow pine	47
Red fir	20
Aspen and cottonwood	3

FOREST.

The forested areas comprise only 5 per cent of the quadrangle, and are confined to the southwest corner. They lie almost wholly within the limits of Yellowstone Forest Reserve in T. 2 S., R. 14 E.; T. 3 S., Rs. 14 and 15 E.; T. 4 S., Rs. 14 and 15 E. Where not devastated by fire, they carry well-stocked stands of red fir, limber pine, and lodgepole pine, with small proportions of Engelmann spruce in the canyons and on the northern slopes. The red fir is the dominant species, forming 65 per cent of the stands, followed by lodgepole pine with 40 per cent, while limber pine adds somewhat less than 5 per cent. The timber is extremely difficult of access, owing to the broken character of the ground where it grows. Most of the timber is either a pole growth or else so short, stocky, and knotty that it is unfit for mill timber. Fully 85 per cent is only valuable for pole and fuel timber. The total volume of timber in the quadrangle is shown in the subjoined table.

Total stand of timber in the Big Timber quadrangle, Montana.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	15,000,000	45,000,000	47,700,000
Lodgepole pine	1,000,000	6,250,000	6,430,000
Yellow pine	40,000,000	70,000,000	77,200,000
Red fir	34,000,000	32,000,000	38,120,000
Engelmann spruce	670,000	550,000	670,600
Aspen and cottonwood		4,700,000	4,700,000
Total	90,670,000	158,500,000	174,820,600

The forested area has been cut over in the upper Deer Creek drainage on areas aggregating 200 or 300 acres. The woodlands have been culled in most of the accessible places, the cut amounting to less than 5 per cent.

Fires have swept the forest in recent years and burned up the timber on 18,000 acres. The woodlands have also been overrun by fire, but most of the damage has been confined to destruction of the young growth.

Reproduction in the forested areas is abundant, the leading species in the restockage being red fir at the lower and middle elevations and logepole pine at the higher.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

BRANNER
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FOREST CONDITIONS

IN THE

LITTLE BELT MOUNTAINS FOREST RESERVE, MONTANA, AND THE LITTLE BELT MOUNTAINS QUADRANGLE

BY

JOHN B. LEIBERG

WASHINGTON
GOVERNMENT PRINTING OFFICE
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 10, 1904.

SIR: I have the honor to transmit for publication, as a professional paper, a report by Mr. J. B. Leiberg on the forest conditions and land classification of the Little Belt Mountains Reserve and adjacent regions.

Very respectfully,

HENRY GANNETT,
Geographer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

FOREST CONDITIONS IN THE LITTLE BELT MOUNTAINS FOREST RESERVE AND THE LITTLE BELT MOUNTAINS QUADRANGLE.

By John B. Leiberg

LITTLE BELT MOUNTAINS FOREST RESERVE.

LOCATION AND EXTENT.

The Little Belt Mountains Forest Reserve was established by Executive proclamation, dated August 16, 1902, and its boundaries described as follows:

"Beginning at the southeast corner of township sixteen (16) north, range ten (10) east, principal meridian, Montana; thence southerly to the point for the northwest corner of township fourteen (14) north, range eleven (11) east; thence easterly to the point for the northeast corner of section four (4), said township; thence southerly along the surveyed and unsurveyed section lines to the point for the southeast corner of section thirty-three (33), said township; thence easterly to the northeast corner of township thirteen (13) north, range eleven (11) east; thence southerly along the surveyed and unsurveyed range line, allowing for the proper offset on the third (3rd) standard parallel north, to the point for the southeast corner of township twelve (12) north, range eleven (11) east; thence easterly along the unsurveyed township line to the point for the northeast corner of township eleven (11) north, range thirteen (13) east; thence southerly along the range line to the southwest corner of township ten (10) north, range fourteen (14) east; thence westerly along the township line to the point for the southwest corner of township ten (10) north, range ten (10) east; thence northerly to the northwest corner of said township; thence westerly to the point for the southwest corner of section thirty-four (34), township eleven (11) north, range nine (9) east; thence northerly along the unsurveyed section lines to the point for the northwest corner of section three (3), said township; thence westerly to the point for the northwest corner of said township; thence northerly along the unsurveyed range line to the point for its intersection with the third (3rd) standard parallel north; thence westerly along said unsurveyed parallel to the point for the southwest corner of section thirty-four (34), township thirteen (13) north, range eight (8) east; thence northerly along the unsurveyed section lines to the point for the northwest corner of section twenty-two (22), said township; thence westerly along the unsurveyed section lines to the point for the southwest corner of section eighteen (18), said township; thence northerly along the surveyed and unsurveyed range line to the southeast corner of township sixteen (16) north, range seven (7) east; thence easterly along the surveyed and unsurveyed township line to the southeast corner of township sixteen (16) north, range ten (10) east, the place of beginning."

The area of the tract thus set apart amounts to 501,120 acres.

CLASSIFICATION OF LANDS.

The lands in the reserve are classified as follows:

Classification of lands in the Little Belt Mountains Forest Reserve.

	Acres.
Forested	237,810
Wooded	25,140
Nontimbered	238,170
Total	501,120

The nontimbered lands at present comprise almost 50 per cent of the reserve. As here classified they include also the temporarily deforested areas—the badly burned tracts—on which the forest has been practically destroyed by fires since the Indian occupancy of the region, and on which only a very sparse restockage has set in. The nontimbered lands are classified as follows:

Classification of nontimbered lands in the Little Belt Mountains Forest Reserve.

	Acres.
Badly burned	111,600
Agricultural	9,250
Grazing	99,070
Bare rocks	18,250
Total	238,170

If the badly burned tracts are restocked there may be an increase in forested areas of 111,600 acres, making the total forest land 349,410 acres, or nearly 70 per cent of the reserve, while the area of the nontimbered tracts will be 126,570 acres. It is not improbable that in addition to the restocking of the badly burned tracts, certain of the grazing areas, which really consist of ancient fire glades created during the Indian occupancy of the region, may, in the course of time, again come under forest cover. Should such be the case, 50,000 acres may be added to the timber land in the aggregate, giving it a grand total of nearly 400,000 acres, or 80 per cent of the reserve. This may be regarded as the possible future forest acreage of the reserve. The remainder, or 101,120 acres, will always remain in part comparatively thinly stocked woodland, and in part grazing or agricultural lands at low elevations. The bare, rocky exposures and high subalpine areas will never bear a forest, owing to absence of soil and severe climatic conditions.

TOPOGRAPHY.

RELIEF.

About half of the reserve is in the southeast portion of the Little Belt Mountains, and the other half is comprised in a secondary system of ridges which stretches northward from the main range and is variously called the Neihart Baldy-Yogo ridge or the Neihart Baldy-Porphyry Peak ridge, the names being taken from prominent elevations situated along its crest.

The main range of the Little Belts occupies the southern and a small part of the northern and central portions of the reserve. The Little Belt Range is a limestone uplift seamed by numerous dikes of eruptive rock and with extensive areas of metamorphic rocks. Toward the northeast it sends out long spurs which form divides between the tributaries of Judith River, while the ridges which radiate from the southern slope of the axis are short and steep and constitute divides between canyons draining directly into Musselshell River. The crest of the main ridge is mostly narrow, but in places it broadens and forms small plateau areas, as at the head of Lost Fork of Judith River. The high crest line is not continuous, for, beginning at the head of Spring Creek, the range is interrupted by three gaps at the head of Spring, Daisy Dean, and Haymaker creeks. These gaps divide the Little Belts into three great blocks and throw the ultimate heads of the three creeks named above, as well as the summit line of the range, into a low, marshy flat that originally formed part of the South Fork of Judith Basin, from which stream the three creeks named are separated only by low gravel hillocks 20 to 40 feet high. I have named the blocks formed by these gaps, beginning on the most easterly, as follows: Twin Peak block, Haymaker block, Daisy Dean block. The greatest altitude reached by the main range within the reserve is 8,400 feet; its mean elevation is approximately 7,300 feet.

Most of the secondary range, at least its higher areas, is formed of a mass of igneous rock. The radiating ridges on the eastern slopes of the main axis are rather long, narrow, and winding, occasionally rising in low peaks or falling away in shallow saddles. The spurs on the western slope are short and steep. The main ridge is narrow, comparatively straight, and with slight variations from the 7,400-foot level in all of its southern portions. There is, however, a gradual rise toward the north until the ridge culminates in the rough and rugged massifs which constitute Yogo Peak and Neihart Baldy, whence short, rough, and rocky spurs radiate in every direction and fill the northern part of the reserve with a mass of winding ridges and canyons. The highest point on the secondary ridge, which is also the highest point in the reserve, is reached in Neihart Baldy, 9,000 feet above sea level. The average elevation of the reserve, exclusive of the canyons and valley bottoms, is, approximately, 6,900 feet.

The canyon system consists of troughs, long and comparatively narrow in their central and lower areas, the larger usually widening into broadly elongated or semicircular basins at the heads. They often contract into narrow gorges at some point along their course, and in the limestone areas almost invariably display a line of castellated cliffs along their upper breaks. The slopes commonly are very steep and below the line of cliffs are deeply covered with rough talus accumulations.

DRAINAGE.

The principal drainage basins in the reserve are as follows: 1. The upper areas of Belt Creek, composed of (*a*) heads of main Belt Creek; (*b*) all of Dry Fork of Belt Creek. 2. Wolf Creek drainage, composed of (*a*) upper and central areas of Dry Wolf; (*b*) upper one-half of Running Wolf. 3. Judith River drainage, composed of (*a*) all of Yogo Creek, which may be regarded as the north fork of the river; (*b*) all of Middle Fork Judith; (*c*) all of Lost Fork of Judith; (*d*) all of South Fork Judith. 4. Tributaries of Musselshell River, consisting principally of Spring, Daisy Dean, and Haymaker creeks.

Most of the run-off from the reserve areas is carried by Judith River, the reserve serving as a large natural reservoir, which is of great importance owing to irrigation along the lower course of that stream. The next largest volume is carried by Belt Creek, a stream also utilized for purposes of irrigation outside the reserve areas. The other streams heading within the reserve are of minor importance, Spring and Daisy Dean creeks on the Musselshell slope being the only ones there that carry any considerable quantities of water. A large number of the smaller canyons are dry throughout most of the year. Especially is this the case where the entire length of the canyon lies in the limestone strata. The extensive fissuring to which the sedimentary rocks of the reserve have been subjected has opened cracks in all directions, through which much of the downfall is swallowed up, never to reappear, at least not on nearby areas.

The reserve contains two small lakes. One is situated on the eastern flanks of Neihart Baldy near the summit. The other lies at the head of Richmond, or Trail, Creek, in T. 11 N., R. 9 E., and is marshy, with a small grass-free place in the center.

MINING AREAS AND MINERALS.

The larger portion of the reserve is a nonmineral region or, at least, is not known to contain valuable or workable ore deposits. The mineralized areas so far opened, and either developed to producing capacity or in a prospecting stage, are as follows: The Neihart district, in T. 14 N., R. 8 E.; the Barker district, in T. 15 N., Rs. 8 and 9 E.; the Wolf Creek districts, in T. 14 N., R. 10 E.; the Sapphire district, in T. 13 N., R. 11 E.; the Yogo district, in T. 13 N., R. 13 E.; and the Spring Creek district, in T. 10 N., R. 10 E.

Of these districts the Neihart and Barker have been important centers of ore production. As they were chiefly silver camps the low price of this metal has brought on a gradual decline in their importance and activity. The Barker district has practically ceased producing ore, and comparatively little is extracted from the mines at Neihart. East of Barker and across the divide in the Wolf Creek drainage are a number of mining claims, mostly in the prospecting stage. One or two have produced and shipped small quantities of ore, with silver as the leading value. Placer claims have been worked to a limited extent in the valleys of the Dry Wolf drainage. Beds of specular iron ore, said to be of considerable extent, occur in the canyons of Running Wolf Creek. They have not been developed. The Sapphire mine is not a placer deposit, as is commonly supposed, but a dike of eruptive rock with the gems in place. The mine was being actively worked at the time the examination was made. The Yogo district is a region of abandoned quartz prospects and placer locations. The Spring Creek district contains several properties with copper apparently as the chief value. None of the claims are developed to producing capacity.

In addition to the districts enumerated there are isolated mineral deposits of small extent in various localities, principally at the heads of Middle Fork of Judith River. It is not improbable that mineralized areas will be discovered elsewhere in the reserve, particularly at the head of South Fork of Judith River, where extensions of the Sapphire district may be expected to occur.

AGRICULTURAL LANDS.

The lands either occupied or suitable for agricultural purposes, comprising 9,250 acres, consist of bottom lands in the different canyons and of a few small tracts in the foothill region, chiefly in T. 15 N., R. 11 E., where they aggregate 2,800 acres, the largest area of cultivable land in any township in the reserve. Nearly all of the agricultural lands are so situated that irrigation is necessary to make them productive. The areas actually under cultivation do not exceed 1,000 acres. The largest proportion of them are situated in T. 15 N., Rs. 9 and 10 E., and in T. 13 N., R. 10 E.

GRAZING LANDS.

The grazing lands have an area of 99,070 acres. To this may properly be added the woodlands, which are more or less completely grassed over and have long been used for pasture. Including these tracts, the available grazing land comprises a grand total of 124,210 acres, classified as follows:

Classification of grazing lands in the Little Belt Mountains Forest Reserve.

	Acres.
Foothills	40,000
Woodlands	25,140
Ancient fire glades, chiefly subalpine, and other nontimbered tracts in that zone, collectively called "parks"	59,070
Total	124,210

The grazing areas in the foothills are confined to tracts having an elevation between 5,000 and 6,000 feet. They are situated as follows: In T. 15 N., R. 10 E., the two eastern tiers of sections; in T. 10 N., Rs. 10 and 11 E., the first southern tier of sections; in T. 10 N., R. 12 E., the two southern tiers of sections; and in T. 10 N., R. 13 E., all except the north tier of sections. All these tracts are timberless, or contain only scattered trees of limber pine, yellow pine, and red fir, and occasionally some juniper scrub; they are situated below the line which marks the lower limit of forest, and owing to semiarid conditions can never become stocked with forest trees; they have been well covered with a grassy sward, but have long been too closely pastured in most localities by both cattle and sheep, and have a low grazing value at the present time.

The woodlands range in altitude from 5,500 to 6,500 feet. Most of the tracts are situated in T. 13 N., R. 11 E., but scattered areas occur throughout the southern tier of townships. Originally they had a ground cover composed of bunch grass and trailing juniper, and in some localities they still retain a fair amount of grass, but, as they have long been used as cattle range and sheep runs, much of the land has been too closely pastured, particularly where the sheeping has been concentrated in limited tracts. The ground cover of juniper remains and is spreading into the grassy areas.

The remainder of the grazing lands consists of ancient fire glades and of tracts nearly bare of forest owing to their position near timber line. Some of the fire glades occupy portions of bottom land in the larger canyons; some are on the southern slopes of the mountains; but most of them lie on the summits of the ridges and divides, between 7,900 to 8,500 feet elevation. These openings are known as "parks." Above the 7,800-foot level they are abundantly and evenly covered with a tough, nearly continuous, sward of subalpine grasses and sedges, and on the slopes and bottoms of canyons by interrupted growths of bunch grass and weeds.

All of the valley areas belonging to this class of grazing lands have long been pastured by cattle and horses, and possibly by sheep, but only in lesser degree. Here and there they show effects of overgrazing, but in the main are in fair condition. They comprise in the aggregate 10,000 acres, of which 2,000 acres are situated in the southern tier of townships in the Musselshell drainage, 5,000 acres in the Judith River basin, and the rest in valleys of various small creeks in the two northern tiers of townships.

The subalpine portions of the grazing lands have an area of 40,000 acres. Owing to the luxuriant growth of grass they are by far the most valuable of the pasture areas in the reserve, but are utilized only by the few prospectors who annually visit them, the great number of insect pests which infest them rendering them almost useless for cattle or horse ranges. In former years they may have been used for sheep pasture, but evidently never very extensively, as none of the tracts show signs of overgrazing. The largest areas of these grazing lands occur along the summit of the Yogo-Porphyry Peak ridge, along the summit and upper slopes of the Yogo-Neihart Baldy ridge, at the head of Lost Fork of Judith River, and on the summit of the big blocks of limestone which lie along the main axis of the Little Belt Mountains, between the head of Daisy Dean Creek and Twin Peaks, in T. 11 N., Rs. 12 and 13 E., where some tracts contain several thousand acres unbroken by lines or stands of forest. All of the tracts, with the exception of 3,000 or 3,500 acres near Yogo Peak and on the summit of Neihart Baldy, owe their origin to fire and mark the site of former stands of subalpine forest.

WOODLAND.

The woodlands, with an area of 25,140 acres, are in the foothill regions in the southern, eastern, and northern townships of the reserve. They carry thin lines, small copses, and scattered trees of limber pine, yellow pine, and red fir. Practically they have no value for silvicultural purposes. They are, however, capable of bearing a larger amount of timber than they now do, but their position within areas of semiaridity or subhumidity will always preclude any close and extensive stockage of forest. These lands include the east half of T. 13 N., R. 11 E., containing 12,000 acres, and scattered, irregular tracts in the southern tier of townships, namely: 6,000 acres in T. 10 N., R. 10 E.; 1,040 acres in T. 10 N., R. 13 E., and 5,000 or 5,500 acres in T. 15 N., R. 10 E., the northeast corner of the reserve.

FOREST CONDITIONS.

COMPOSITION, AND REGIONAL AND ALTITUDINAL DISTRIBUTION.

Most of the forest in the reserve is made up of coniferous species, as follows:

Species in Little Belt Mountains Forest Reserve.

Limber pine	Pinus flexilis
Lodgepole pine	Pinus murrayana
Yellow pine	Pinus ponderosa
White-bark pine	Pinus albicaulis
Red fir	Pseudotsuga taxifolia
Subalpine fir	Abies lasiocarpa
Engelmann spruce	Picea engelmanni

There is also a small percentage of deciduous-leaved trees, mostly represented by aspen, cottonwood, wild cherry, and various species of alder and arborescent willows. The percentages of the different species, averaging the entire reserve and basing the estimates on basal diameters exceeding 3 inches, are as follows:

Percentage of species in Little Belt Mountains Forest Reserve.

	Per cent.
Limber pine	8.2
Lodgepole pine	34.2
Yellow pine	.07
White-bark pine	.009
Red fir	44.7
Subalpine fir	1.4
Engelmann spruce	11.4
Aspen and cottonwood	.021

Owing to the climatic conditions in the areas surrounding most of the reserve the arrangement and general distribution of the different species of trees are somewhat complex. A large portion of the tract consists of a narrow mountain axis flanked by areas with a moderately high mean summer temperature, which are arid or semiarid by reason of comparatively low elevation. The result of this combination of climatic conditions and geographic position is that the species which normally would remain in the lower zones of the forest are found at altitudes where they are mingled with the species of the subalpine zone. As the mountain regions of the reserve are variously influenced by the climatic features of the plains, it follows that the different portions of the reserve exhibit this intermingling of forest zone in different degrees.

The lowest fringe of forest adjoining the woodlands, or in some cases directly abutting on the nontimbered plains, consists of red fir, limber pine, and yellow pine. It lies at elevations of between 6,000 and 6,500 feet. Above this latter altitude the yellow pine soon thins out and disappears. The limber pine

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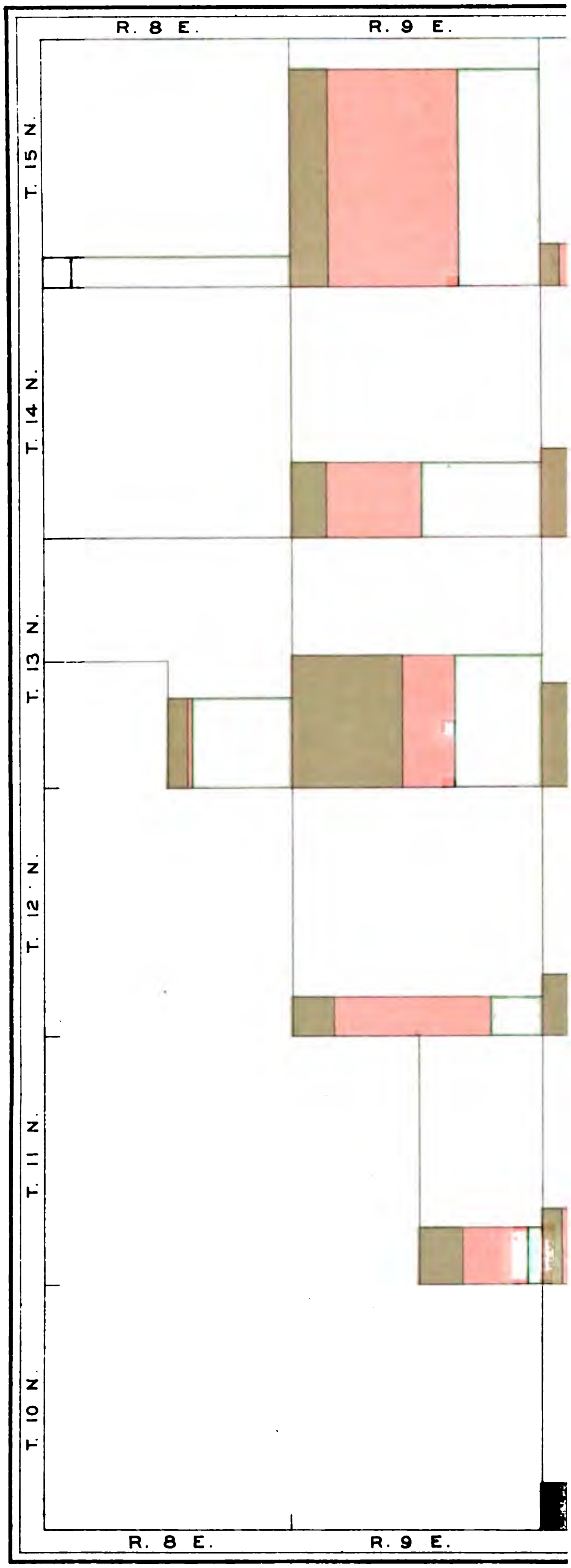

The different species are found throughout the reserve within their altitudinal limits with the exception of the white-bark pine, which is confined to the high summits of Mixes Baldy, Yogo Peak, and Neihart Baldy. The heaviest and most extensive areas of lodgepole pine are in the Belt Creek drainage, where it forms 85 per cent of the forest, and in the upper portion of South Fork of Judith basin, where it forms 99 per cent of the stand on 30,000 or 35,000 acres. In the Musselshell drainage it constitutes only a small percentage of the timber, its place being taken by red fir.

The limber pine has a fairly uniform distribution, but is rather more plentiful in the northeast quarter of the reserve than elsewhere. The yellow pine is comparatively infrequent in the Belt Creek drainage, and is more common in the lower areas of Judith River basin, although it is nowhere abundant. It is found found in greatest amount on the Musselshell slopes, particularly in the valley of Spring Creek, in T. 10 N., R. 10 E. Its relative scarcity and uniformly poor form show that this region is not adapted to its extensive development.

The red fir is very abundant throughout Judith River basin and on the slopes in the Musselshell drainage. In Judith River basin it is commonly associated with lodgepole pine and Engelmann spruce, forming from 20 to 65 per cent of such mixed stands. On the Musselshell slopes it frequently composes 85 to 95 per cent of the forest, the remainder being limber pine, yellow pine, and Engelmann spruce.

The subalpine fir occurs on all the high ridges throughout the reserve. Here it is distinctly what its name implies—a subalpine species. With the exception of the white-bark pine and the yellow pine none of the trees composing the forest are more restricted in their range.

The spruce occurs in all portions of the reserve, but never in pure growth stands, its proportion varying from 10 to 80 per cent. The highest percentages are reached in veteran stands at middle and lower subalpine heights; the lowest percentages where the species is in mixed stands of well-stocked lodgepole pine at middle elevations. The heaviest and best stocked stands of spruce occur at the head of Middle Fork of Judith River in growths 300 to 350 years old.

Aspen and cottonwood, together with various species of alder, arborescent willows, cherry, service berry, and thorn, represent the broad-leaved components of the forest. Their proportion in the general mass is insignificant. They form fringes in the lower areas of the different valleys, usually along the streams. Occasionally the aspen spreads over the slopes and ascends to altitudes of 7,500 feet or even higher.

The general composition of the forest as it now stands is not a normal one. It has been greatly modified and altered by fires both during the time the Indian held possession of the country and since the advent of the white man. As a result of fires the percentage of lodgepole pine has been increased and that of red fir and Engelmann spruce decreased. A forest of normal composition, such as would cover the reserve were fires wholly eliminated and cutting closely regulated during a century and a half, should consist, approximately, of 62 per cent red fir and 25 per cent Engelmann spruce, while the remainder would be made up of lodgepole pine, subalpine fir, and small proportions of limber and white-bark pine.

AGES AND DIMENSIONS OF TREES.

Most of the forest in the reserve is composed of stands in the sapling or pole stage of growth, 80 per cent being less than 150 years old. The veteran stands are almost wholly confined to the summits of the higher ridges, to the upper portion of Middle Fork of Judith basin, and to the canyons in the Musselshell drainage, but single trees or small copses of old growth are also scattered throughout the pole stands. The age of the veteran stands varies from 250 to 350 years, most of the old growth in the subalpine areas being nearer 250 years. The younger stands show a moderate degree of variation in their relative ages. Most of them occur in large bodies of nearly even age, indicating that the ancient fires, like the more recent ones, devastated large areas simultaneously. Of the forest less than 150 years of age about 36 per cent, covering in the aggregate 52,000 acres, is less than 45 years old.

The age of the timber on the slopes and summits is shown in the following table:

Age of timber on slopes and summits.

Species.	Height.	Diameter, breast high.	Age.
	Feet.	*Inches.*	*Years.*
Lodgepole pine	60–80	8–10	135–175
Limber pine (foothills)	30–40	14–16	120–150
Limber pine (7,500 to 8,000 feet)	30–40	14–16	250–280
White-bark pine	25–35	20–25	250–300
Subalpine fir	40–50	10–14	130–150
Engelmann spruce	50–75	16–25	150–200
Red fir (middle elevations)	60–80	10–14	120–150
Red fir (high altitudes)	30	8–9	120–150

Most of the timber is of slender growth even when mature. The largest specimens observed were as follows: Red fir, 5 feet in diameter; white-bark pine, 3 feet; Engelmann spruce, 4½ feet; limber pine, 3 feet. These diameters were exceptional.

Low ratios of soil humidity, induced by the not overabundant rainfall; rapid drainage, caused by steep slopes; thin soil; lack of duff or humus to prevent surface evaporation; and a sterile soil—all cause the growth to be exceedingly slow. Exceptions occur in the swales and bottom lands, where there is greater moisture and the soil is deeper, but the great body of the forest requires from one hundred to one hundred and twenty years to yield merchantable poles and from one hundred and twenty to two hundred and fifty years to supply sizeable saw timber.

CHARACTER, VALUE, AND VOLUME OF MERCHANTABLE TIMBER.

The chief value of the forest is in its effect on the conservation and regulation of the run-off. From a commercial point of view, the only product of value consists of pole and fuel timber, as there is comparatively little, at least in the easily accessible areas, large enough to furnish saw logs. The mill timber everywhere is of poor quality.

A greater volume of mill timber is obtainable from the red fir than from any other species. It has been less cut because its tough, stringy wood is not suited for mill timber, its rapid taper unfits it for poles of any considerable length, and it occurs most plentifully in areas remote from market.

The lodgepole pine comes next in volume. Owing to its abundance near mining centers it has been more largely cut than any other species, notwithstanding the fact that it is less durable and much inferior generally to other common and accessible species.

The spruce ranks after the lodgepole pine in volume of mill timber. Little of this species has been cut because the best and thickest stands are difficult of access and remote from transportation and points of demand.

The yellow pine is cut wherever accessible. The proportion of this species and of white-bark and limber pine is so small that altogether they do not enter appreciably into the quantity of mill timber that the forest is capable of supplying.

In the volume of pole and fuel timber the lodgepole pine heads the list, having nearly three times the volume of the red fir. Next in rank comes the red fir, followed by the spruce, while of the less abundant species limber pine shows a relatively large volume owing to its occurrence mostly as an old growth.

The yield of mill timber runs low everywhere throughout the reserve. It varies from 500 to 7,000 feet B. M. per acre, but the latter amount is found only in veteran stands of Engelmann spruce. The low yield of mill timber is due to the scattering and intermittent grouping of trees large enough to cut for saw logs.

On hundreds of acres large tracts of close-set, middle-aged stands of lodgepole pine and red fir will not yield a single saw log, and the subalpine areas contain only scattered trees of the necessary dimensions. When squared the average diameter of the mill timber throughout the reserve is probably $9\frac{7}{8}$ or $9\frac{15}{16}$ inches. As ordinarily cut, from 15 to 20 logs are required to produce 1,000 feet B. M.

The yield of pole and fuel timber varies from 400 cubic feet per acre in the thinly stocked woodlands to 5,000 cubic feet per acre in fully stocked lodgepole-pine stands such as occur at the head of South Fork of Judith River. The comparatively low average of this class of timber is due to the thin subalpine stands and to the large areas covered with 40 to 50 years old growth too slender and immature to be taken into the account. No timber in the reserve can at all approach the lodgepole pine in possible yield of pole and fuel timber. Were all the tracts capable of producing this species stocked to their full capacity 60 per cent of the reserve would yield at least 5,000 to 5,500 cubic feet per acre.

The total volume of mill timber in the reserve, estimated on the basis of 8 inches diameter, breast high, and 10 feet of available bole, with the amount contributed by each species, is shown in table below:

Volume of mill timber in the Little Belt Mountains Forest Reserve.

	Feet B. M.
Limber pine	1,050,000
Lodgepole pine	70,100,000
Yellow pine	6,300,000
Red fir	111,650,000
Engelmann spruce	52,850,000
Total	241,950,000

The above volume gives an average stand of nearly 1,020 feet B. M. per acre for the forested areas of the reserve.

The volume of pole and fuel timber, basing the estimates on diameters of not less than 4 inches, is as follows:

Volume of pole and fuel timber in the Little Belt Mountains Forest Reserve.

	Cubic feet.
Limber pine	14,895,000
Lodgepole pine	239,340,000
Yellow pine	400,000
White-bark pine	400,000
Red fir	113,085,000
Subalpine fir	2,520,000
Engelmann spruce	41,170,000
Total	411,810,000

The above total gives an average of nearly 1,730 cubic feet per acre. If the mill timber is converted into cubic measure on the basis of 180 cubic feet to 1,000 feet B. M., and added to the pole and fuel timber, the average is brought up to 1,914 cubic feet per acre.

CUTTING.

The tracts logged to exhaustion and those merely culled comprise 59,600 acres, or nearly 25 per cent of the forest area. Most of these logged and culled districts are situated in the northern and eastern tiers of townships. The area cut over in the southern townships is insignificant, comprising but a few hundred acres. The central areas have hardly been touched.

The largest area of cut-over forest, 30,000 acres, is in the Belt Creek drainage in T. 14 N., R. 8 E., and in T. 15 N., Rs. 8 and 9 E. In T. 14 N., R. 8 E., and T. 15 N., R. 8 E., there remain but a few hundred acres of accessible merchantable timber not culled over, while in T. 15 N., R. 9 E., 70 per cent of the merchantable forest has been cut. The large amount of cutting on these tracts is due to their proximity to the mining camps at Neihart and Barker, and also to the circumstance that Tps. 14 and 15 N., R. 8 E., are bisected by a branch line of the Great Northern Railroad, affording convenient transportation for the timber products to outside points. The cutting has been for mill timber, fuel, fencing, mine props, and smelter poles. All of these classes of timber have been exported and all have also been used locally, except smelter poles. Cutting was active until the reserve was created, since which time it has gradually declined. At present only a small amount is cut to supply the agricultural areas.

The sawmills which formerly operated in the reserve have mostly moved away or closed down. There is one mill in the canyon of Dry Fork of Belt Creek, another in Dry Wolf Canyon, and another in Spring Creek Valley, in T. 10 N., R. 10 E.—all small mills with a capacity of a few thousand feet each a day and not in active operation at the time the examination was made. With the closing of the mines at Neihart and Barker most of the local demand ceased. The Sapphire mine in T. 13 N., R. 11 E., draws on the reserve for limited quantities of mining timber, obtaining most of it from Yogo Canyon. Heretofore large quantities of mine props have been shipped to the coal mines at Belt and Sand Coulee, but this demand appears also to have fallen off since the forest-reserve regulations governing cutting came into force. Up to the winter of 1902 there was a fair demand for smelter poles at Great Falls, Mont., and very large quantities of pole timber were cut and shipped to that place. These poles are used in the copper smelter at Great Falls, being introduced with the charge to effect certain changes in the ore. They are cut 30 feet in length with diameters varying from 5 to 8 inches at the butt, to 3 or 3½ inches, or less, at the small end. The poles are sold by weight—345 pounds being considered equivalent to one pole. They are cut from green timber, lodgepole pine being preferred because it tapers less within the 30-foot length than red fir or spruce. Most of the poles have been cut around Neihart and Barker. Owing to the Government stumpage and the rule requiring the piling of tops and limbs it is claimed that poles can no longer be shipped with a profit.

The cut-over areas have uniformly been left in bad condition. No attempt has been made to pile tops and limbs. Thousands of poles, mine props, and saw logs have been wasted by being left to rot where felled. In a few localities the earlier cut areas have been cleaned up by fire, which also burned the uncut timber, but generally the waste, both in the forest and around the sawmill settings, thickly litters the ground in all directions.

While the streams in the reserve are not drivable, as a rule, most of the really valuable merchantable timber is not particularly difficult of access. Logging roads can be constructed at moderate cost, and in those canyons where road making would be difficult and expensive, particularly in the Musselshell drainage, there is no timber worth logging.

BURNS.

The areas burned over since the advent of the white man comprise in the aggregate 111,600 acres. The devastation has been wrought during the last thirty-five or forty years, chiefly since the location of Neihart and Barker mining camps. However, during the Indian occupancy there were many fires, as shown by the age of the forest and the composition of the stands.

No large area of the reserve has remained untouched by fire during the last one hundred and fifty years. The most extensive unburned tracts are at the head of Middle Fork of Judith River and contain 3,000 or 4,000 acres. They have not been touched by fires during the last three hundred and fifty years. Since the advent of white men fires have been most severe and widespread in the two northern tiers and the most southern tier of townships, and during the last century and a half of Indian occupancy the most extensive burns were at the head of South Fork of Judith River, extending across the main divide of the Little Belt Mountains and including most of the lower slopes of the Musselshell drainage. The age and composition of the forest show that relatively more ground has been burned over during the occupancy of the region by the white man than during the last three generations of Indians, as during the forty years of the white man's occupancy 22 per cent of the reserve was laid waste, and during the preceding one hundred and ten years 58 per cent was burned over.

In this region fires almost invariably totally destroy the forest, except in the thin subalpine stands. The timber is rarely consumed by the first fire. Usually it is killed and left standing, and is later overthrown by wind and destroyed by future fires. The destructiveness of the fires is due to the vast amount of litter that accumulates in the closely-stocked stands. Below the middle of the subalpine zone all reforestations after fires begin with stands stocked excessively close. As the forest becomes older and the natural processes of pruning set in, great quantities of dead wood begin to litter the ground and furnish material for future disastrous conflagrations. There is little humus or duff on the forest floor to assist in spreading the fires, but on the northern slopes a moss cover, 2 to 4 inches in depth, is commonly present, and during the height of the dry season burns readily where at all abundant.

RESTOCKAGE.

In the woodlands and in the subalpine forest young growth is scanty and on the whole deficient, whether as restockage after fire or as the ordinary renewals in the growing stands. In the forest lying between these two zones young growth is abundant, except in the already fully stocked lodgepole-pine and red-fir stands, and in areas on which fire-killed and fallen timber has been consumed in a clean-burning fire.

The young growth in the woodlands is composed of limber pine, yellow pine, and red fir, the first-named species predominating. The growth is thin and scattering and is greatly retarded by the extensive and close matting of creeping juniper. In the upper subalpine zone there is sufficient young growth to keep the stands stocked slightly above their present percentage, as young spruce, subalpine fir, limber pine, and lodgepole pine are slowly reoccupying the grassy areas which formerly were clothed with forest. It is evident that the subalpine forest as a whole has a low reproductive ratio, and it is also clear that when entirely destroyed by fire a grassy turf takes the place of forest and remains indefinitely. Some of the grassy fire glades at subalpine elevations, into which the young growth is now slowly creeping, must have remained in their present nontimbered condition for centuries. They are full of buffalo trails and wallows, showing that they served for long periods as summer pastures. That they once were covered with forest may be inferred from the fact that similar grass tracts, in process of formation as the result of fires kindled by the white man, and showing every stage in the transformation from half or completely burned forest to grass land, are met with in many localities along all the high divides throughout the reserve.

Below the subalpine levels the forest generally is so closely stocked that little additional growth has a chance of surviving the seedling stage. On the burned-over areas in the Belt Creek drainage excessively close-set stands of lodgepole pine have taken possession of the ground. There is a fairly good restockage on the burns in the drainage basin of Dry Wolf, and partially so in that of Running Wolf Creek. But the reforestations on the burns on Taylor Peak and on the northern tier of sections in T. 14 N., R. 10 E., are extremely thin and deficient. Reforestation also is deficient on the burned-over tracts in the southern tier of townships on the Musselshell slopes.

Within its altitudinal limits lodgepole pine is the leading species in all restockages in the central and northern portions of the reserve. In the southern areas, at least on the Musselshell slopes, red fir becomes the chief species. In the central and northern portions of the reserve lodgepole pine is sure to replace the red fir in practically every case. In the southern areas red fir follows red fir, or the ground remains nontimbered, unless the seepage is considerable, in which case small quantities of lodgepole pine may accompany the red fir as well as lesser proportions of Engelmann spruce. The variations in the composition of the young growth are caused by variation in the degree of aridity, as the red fir is better able to resist arid conditions than the lodgepole pine.

In some localities where the lodgepole pine has been logged and large openings made, red fir and spruce show a marked tendency toward larger proportions than they displayed in the uncut stands, but in general the lodgepole pine has attained such proportions in the reserve that, no matter how carefully the forest is handled, it is bound to retain its superiority, at least during the next hundred years, to the exclusion of better trees.

TOWNSHIP DESCRIPTIONS.

Township 10 North, Range 10 East.

Topography.—Most of the township is situated in the valley of Spring Creek, a broad, terraced depression inclosed on the east and west by comparatively low, much-broken spurs, which stretch south from the main range of the Little Belt Mountains in the township on the north.

Mining.—Prospects on quartz ledges are scattered throughout Spring Creek Valley.

Minerals.—Copper and gold chiefly.

Soil.—Comminuted limestone débris overlain and mixed with thin loam.

Agricultural adaptability.—Small tracts in Spring Creek bottoms are cultivable. The aggregate area amounts to 250 to 300 acres.

Grazing capacity.—The south half of the district is thinly wooded and forested, and affords numerous grassy openings suitable for pasturage. It is utilized for cattle range, and as yet has not been overgrazed.

Drainage conditions.—The run-off which originates in the township is of small volume and is carried by Spring Creek. Most of the minor lateral canyons and runs are dry throughout the greater portion of the summer and fall.

Towns and settlements.—The township contains no settlements, though miners' cabins are scattered throughout the mineral-bearing districts. One small sawmill is located on Spring Creek, and two or three farms are situated on the tillable lands in this valley.

Forest conditions.—The forest consists of mixed stands of red fir, spruce, and limber pine, with small proportions of lodgepole pine on the summit of the higher ridges, and here and there lesser percentages of yellow pine. In the eastern portion of the township the stands are continuous and fairly well stocked. In the valley of Spring Creek and on its western slopes the stands are thin, grassy glades and rocky exposures breaking their continuity. The yellow pine in the district is confined mostly to the bottoms of Spring Creek. In general the timber is of slender growth, stocky and limby in the thinly stocked stands.

Woodlands.—Portions of the southern areas are thinly stocked with scattering growth of limber pine and red fir. The stands and copses are set on grassy flats and hillsides, and have only a fuel and pole value.

Cutting.—A block of forest in Spring Creek Valley 3 miles long by one-half to two-thirds of a mile wide has been culled of most of its mill timber, particularly of the yellow pine.

Burns.—Severe burns have ravaged the township during the last six or eight years, and have laid waste most of the forest.

Reproduction.—Restockage is very deficient on all the burned areas. The tendency is toward grass cover in place of forest.

Undergrowth.—Scanty.

Litter.—In the burned tracts litter, consisting of the unconsumed timber, is very heavy and is constantly accumulating. In the green stands litter is light.

Humus.—None.

Classification of lands in T. 10 N., R. 10 E.

	Acres.
Forested	6,540
Wooded	6,000
Nontimbered	10,500
Badly burned	10,200
Logged	600
Agricultural	300
Grazing (woodland)	6,000

Total stand of timber in T. 10 N., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	....	200,000	200,000
Lodgepole pine	....	300,000	300,000
Yellow pine	1,800,000	100,000	424,000
Red fir	5,800,000	4,000,000	5,044,000
Engelmann spruce	700,000	900,000	1,026,000
Total	8,300,000	5,500,000	6,994,000

Composition of forest in T. 10 N., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	1.5
Lodgepole pine	1.5
Yellow pine	2
Red fir	85
Engelmann spruce	10

Composition of the woodland growth in T. 10 N., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	8
Red fir	92

TOWNSHIP 10 NORTH, RANGE 11 EAST.

Topography.—The township consists chiefly of the Daisy Dean block—a great uplift of limestone lying between Spring and Daisy Dean creeks on the Musselshell slope of the Little Belt Range. The block is deeply cut by numerous narrow, cliff-bound canyons, and is completely pierced by the canyon of Daisy Dean Creek.

Mining.—None.

Soil.—The soil throughout the district is thin and stony.

Agricultural adaptability.—Small tracts situated on Daisy Dean Creek near the south line of the township are tilled. They comprise in the aggregate 250 to 300 acres.

Grazing capacity.—The grazing areas are scattered throughout the township and consist of open, grassy hillsides in the southern areas, grassy fire glades in the valley of Daisy Dean Creek, and ancient burns not restocked on the summit of the uplift.

Drainage conditions.—The outflow from the township is small, and is carried mostly by Daisy Dean Creek. Most of the canyons are dry except in the spring.

Towns and settlements.—There are no settlements in the township. One settler occupies a small tract of land in section 28.

Forest conditions.—The forest consists of red fir at the lower and middle elevations, and lodgepole pine, subalpine fir, and Engelmann spruce at the highest altitudes. Most of the red fir is in the pole stage of growth. The timber is uniformly stocky and limby, is difficult of access, and has only a fuel value.

Cutting.—In the southern areas 200 acres have been culled 75 per cent.

Burns.—Most of the north half of the township, formerly well stocked with timber, has been burned over and the forest totally destroyed. The fires have been particularly destructive in the upper and central Daisy Dean drainage, where all the timber, with the exception of a few hundred acres of red fir, has been completely consumed.

Reproduction.—Young growth is scanty throughout the township. There is as yet little or no restockage on the burned-over areas.

Undergrowth.—Consists of a small amount of inconspicuous shrubs.

Litter.—There is a great amount of dead and fallen timber on the burned-over tracts.

Humus.—None.

Classification of lands in T. 10 N., R. 11 E.

	Acres.
Forested	4,040
Nonforested	19,000
Badly burned	12,000
Logged	1,200
Agricultural	300
Grazing	6,000
Bare rocks	700

Total stand of timber in T. 10 N., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		200,000	200,000
Lodgepole pine		3,000,000	3,000,000
Red fir	3,000,000	2,500,000	3,040,000
Engelmann spruce	850,000	730,000	883,000
Total	3,850,000	6,430,000	7,123,000

Composition of forest in T. 10 N., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	3
Lodgepole pine	8
Yellow pine	Scattered trees.
Red fir	84
Engelmann spruce	5

TOWNSHIP 10 NORTH, RANGE 12 EAST.

Topography.—The township is situated on the southern or Musselshell slope of the Little Belt Mountains. The northern half consists of steep, castellated spurs and narrow, rocky canyons; the southern half comprises a rolling foothill region. The average altitude is 6,000 feet.

Mining.—None.

Soil.—Gravelly loam, with gumbo in the southern portions.

Agricultural adaptability.—Owing to lack of water and to its rolling character the region is not adapted to agricultural pursuits.

Grazing capacity.—All the foothill region and many of the slopes in the northern sections are essentially pasture land, and have been so utilized. The pasture land has been badly overgrazed.

Drainage conditions.—The outflow from the township is insignificant. Very little originates within its boundaries, and the stream beds are dry throughout most of the year.

Towns and settlements.—None.

Forest conditions.—The forest is limited to tracts in the northern areas of the district and consists of thin lines and stands of red fir in the canyons and on the northern and western slopes. Mixed with the red fir are small proportions of yellow pine, limber pine, and lodgepole pine. In the extreme northwest corner of the township the highest spurs carry small stands of lodgepole pine and Engelmann spruce. The timber is stocky and limby and is difficult of access for logging operations, owing to steep slopes and narrow canyons.

Woodlands.—The southern portion of the township carries scattered trees and small stands composed of limber and yellow pine. The growth is so sparse that it does not properly come within the woodland classification.

Cutting.—Small tracts in the foothill areas, in the scattered woodland growth, have been cut over.

Burns.—Extensive fires have devastated the northern areas in recent years, involving complete destruction of the timber on the burned-over tracts.

Reproduction.—The reproductive capacity of the forest is low. There is little young growth in the green stands and practically none on the burns. Red fir is the chief species in the restockage.

Undergrowth.—Very little.

Litter.—Light; the fire-killed timber is mostly standing.

Humus.—None.

Classification of lands in T. 10 N., R. 12 E.

	Acres.
Forested	6,400
Nonforested	16,640
Badly burned	6,000
Logged (culled)	1,000
Agricultural	None.
Grazing	10,000
Bare rocks	640

Total stand of timber in T. 10 N., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		300,000	300,000
Lodgepole pine		80,000	80,000
Yellow pine	800,000		144,000
Red fir	6,000,000	4,000,000	5,080,000
Engelmann spruce	2,000,000	500,000	860,000
Total	8,800,000	4,880,000	6,464,000

Composition of forest in T. 10 N., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	5
Lodgepole pine	3
Yellow pine	.3
Red fir	84.7
Subalpine fir	1
Engelmann spruce	6

TOWNSHIP 10 NORTH, RANGE 13 EAST.

Topography.—This township forms the southeast corner of the reserve, and consists of a rolling foothill region on the southern slope of the Little Belt Mountains, with an average elevation of 5,500 feet.

Mining.—None.

Soil.—Thin, gravelly loam; alkaline gumbos in the valley bottoms.

Agricultural adaptability.—The tract is too rolling and has no water for irrigation purposes, and hence is not adapted to agricultural pursuits.

Grazing capacity.—The township is essentially a grazing one. It has been closely sheeped and otherwise pastured, and its present pasturage value is accordingly low.

Drainage conditions.—The run-off is insignificant. Most of the creeks and ravines are dry during the greater portion of the year, and carry water only in the spring.

Towns and settlements.—The settlements are limited to scattered sheep shacks.

Forest condition.—The township contains no forested land.

Woodland.—Small tracts scattered throughout the township bear a very thin growth of red fir and limber pine of no value except for fuel.

Cutting.—Culled over for farm use.

Burns.—None.

Reproduction.—Very scanty. The stands will, however, slowly increase in density and extent if fires are kept down and sheeping excluded, but the tract can never become forested owing to climatic conditions and soil aridity.

Undergrowth.—Extensive mats of *Juniperus procumbens* occur throughout.

Litter.—None.

Humus.—None.

Classification of lands in T. 10 N., R. 13 E.

	Acres.
Forested	None.
Woodland	1,040
Nontimbered	22,000
Badly burned	None.
Logged (culled)	800
Agricultural	None.
Grazing	22,000

Total stand of timber in T. 10 N., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	None.	25,000	25,000
Red fir	None.	85,000	85,000
Total	None.	110,000	110,000

Composition of woodland growth in T. 10 N., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	15
Red fir	85

TOWNSHIP 11 NORTH, RANGE 9 EAST.

Topography.—Of this township only the east half, or 11,520 acres, is in the reserve. At the head of Richmond Creek, in the northeast corner of the township, the main range of the Little Belts breaks down into a low gap, and forms a broad flat, holding a marshy lake that discharges into both the Judith and the Musselshell drainage. The township has an average elevation of 6,800 feet.

Mining.—None.

Soil.—Deep peaty loam in the marshy area, limestone and quartzite débris elsewhere. Small quantities of bowlder drift are scattered over the slopes of the ridges and in the canyons.

Agricultural adaptability.—The district contains no arable land.

Grazing capacity.—The marshy tracts, 250 to 300 acres in all, are used for pastures and hay meadows. In addition to these there are grassy fire glades, amounting to 1,800 acres, on the summit of the main range and along its upper slopes.

Drainage conditions.—The outflow from the township is small. Most of it is discharged into the Judith drainage, only an inconsiderable portion flowing south into the Musselshell basin.

Towns and settlements.—None. Hay claims are located on the marshy tracts, but nobody maintains a residence on them.

Forest conditions.—The forest along the main range consists of scattered copses of limber pine, subalpine fir, and Engelmann spruce set in grassy fire glades. The southern slopes carry stands of red fir, spruce, and small quantities of yellow pine. On the northern slopes lodgepole pine, in nearly pure stands and very thickly stocked, is the prevailing species. The timber is small, scrubby, and limby. It is difficult of access from the northern side of the range, but is readily reached from the southern slopes.

Cutting.—Small quantities have been cut here and there on the lower slopes south of the main range and in the northeast corner of the township.

Burns.—The grassy glades on the summit and slopes of the main range represent ancient burns which have not yet been reforested. In the southern portion 50 per cent of the timber over 1,000 acres has been destroyed by recent fires.

Reproduction.—Deficient and scanty at high elevations in the subalpine forest and on the ancient burns, likewise in the close set lodgepole-pine stands on the northern slopes. There is a moderate amount of young growth on the southern slopes, where red fir forms the leading species.

Undergrowth.—Light.

Litter.—Small amount in the lodgepole-pine forest; little elsewhere.

Humus.—Very thin or altogether lacking.

Classification of lands in T. 11 N., R. 9 E.

	Acres.
Forested	9,470
Nonforested	2,050
Badly burned	1,000
Logged	None.
Grazing	2,050

Total stand of timber in T. 11 N., R. 9 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		890,000	890,000
Lodgepole pine	1,100,000	5,000,000	5,198,000
Red fir	5,000,000	2,000,000	2,900,000
Engelmann spruce	3,200,000	850,000	1,426,000
Total	9,300,000	8,740,000	10,414,000

Composition of forest in T. 11 N., R. 9 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	8
Lodgepole pine	40
Red fir	40
Subalpine fir	2
Engelmann spruce	10

TOWNSHIP 11 NORTH, RANGE 10 EAST.

Topography.—The central and southern areas of the township are situated on the summit of the Little Belt Mountains. The summit is here a broad, plateau-like area. It abounds in shallow depressions and low combs and ridges, partly composed of rock in place, partly of drift material—gravel and bowlders. Along the south line of the township the plateau breaks off sharply by steep spurs and deep canyons to the Musselshell drainage. The northern parts of the township consist of slopes with easy grades, descending from the plateau to the narrow and shallow canyon of South Fork of Judith River, which intersects this part of the district.

Mining.—None.

Soil.—Deep loam in the marshy depressions of the plateau; gravelly and stony on the ridges and slopes.

Agricultural adaptability.—No part of the township is cultivable.

Grazing capacity.—The township is forested throughout and has no grazing areas.

Drainage conditions.—The northern and central portions of the township abound in marshy depressions, springs, and points of seepage, which give rise to one of the principal tributaries of South Fork of Judith River. The southern slopes, draining into the Musselshell basin, shed very little water.

Towns and settlements.—None.

Forest conditions.—Except where ravaged by fire, the township is covered with an extremely close-set forest of nearly pure-growth lodgepole pine, varying in age from 50 to 200 years. Small amounts of red fir occur on the southern slopes of the district, but the aggregate volume of this species is small in comparison with that of the prevailing lodgepole pine.

Cutting.—None.

Burns.—In the southern areas nearly 5 sections have been burned over and the forest destroyed to the extent of 95 per cent.

Reproduction.—Practically none, owing to the excessively close-set stands which are stocked to their utmost capacity.

Undergrowth.—Very light.

Litter.—Great quantities of dead and fallen timber have accumulated in the stands of green forest, while the burned-over areas are choked with the fire-killed timber thrown down by heavy winds.

Humus.—Thin layers of pine needles.

Classification of lands in T. 11 N., R 10 E.

	Acres.
Forested	20,000
Nonforested	3,040
Badly burned	3,000
Logged	None.
Agricultural	None.
Grazing	None.

Total stand of timber in T. 11 N., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	....	500,000	500,000
Lodgepole pine	10,000,000	70,000,000	71,800,000
Red fir	2,000,000	2,000,000	2,360,000
Englemann spruce	1,000,000	3,500,000	3,680,000
Total	13,000,000	76,000,000	78,340,000

Composition of forest in T. 11 N., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	0.2
Lodgepole pine	91.8
Red fir	5
Engelmann spruce	3

TOWNSHIP 11 NORTH, RANGE 11 EAST.

Topography.—The northern and central portions of this township comprise a plateau-like tract cut in different directions with gullies and ravines, which constitute the principal eastern water heads of South Fork of Judith River. The southern areas rise in precipitous slopes, forming the northern declivities of the Daisy Dean and Haymaker blocks. Most, or all, of the tract is situated on the northern slope of the Little Belt main range, and has a mean altitude of 6,800 feet.

Mining.—None.

Soil.—Loam of moderate depth, underlain by gravel and bowlder drift.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—Small areas in the southern portions and grassy glades throughout the balance of the township constitute the pasture lands. No domestic animals range in this district.

Drainage conditions.—The township supplies a moderate amount of run-off to the Judith drainage, scarcely any to the Musselshell. It contains no lakes or tarns, but is well supplied with springs and marshy places.

Towns and settlements.—The township contains no settlements.

Forest conditions.—The northern and central areas are stocked with an almost pure growth of lodgepole pine, set exceedingly close. Most of it is a pole growth 50 to 60 years old. In the high southeast portion of the township the forest assumes the typical subalpine composition. The southern portions bear stands of small, scrubby red fir.

Cutting.—None.

Burns.—There have been extensive fires in southern and eastern portions in recent years, and the timber in most cases has been totally destroyed.

Reproduction.—Owing to the excessively close-set stands there is scarcely any young growth in the green forest. Restockage on the burned-over areas is as yet thin and scattering.

Undergrowth.—Light.

Litter.—Dead and fallen pole timber is present in large quantities in the green forest and on the burned-over tracts.

Humus.—None.

Classification of lands in T. 11 N., R. 11 E.

	Acres.
Forested	14,040
Nonforested	9,000
Badly burned	7,500
Logged	None.
Agricultural	None.
Grazing	1,000
Bare rocks	500

Total stand of timber in T. 11 N., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		500,000	500,000
Lodgepole pine	9,000,000	36,000,000	37,620,000
Red fir	3,000,000	8,000,000	8,540,000
Subalpine fir		400,000	400,000
Engelmann spruce	2,000,000	3,000,000	3,360,000
Total	14,000,000	47,900,000	50,420,000

Composition of forest in T. 11 N., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	3
Lodgepole pine	81.5
Red fir	10
Subalpine fir	.5
Engelmen spruce	5

TOWNSHIP 11 NORTH, RANGE 12 EAST.

Topography.—All of the central and most of the southern areas of the district are situated on the summit of Haymaker block, an uplift of limestone with a level or gently rolling surface and which here forms the summit of the

Little Belt Mountains. Its altitude varies from 7,200 feet to 7,800 feet. In the northern part of the township the block breaks off with precipitous cliffs and scarps to the foothills of Judith River basin, forming a series of bold, prominent bluffs which are conspicuous landmarks of the region. Along the south line of the township the block is indented with the heads of ravines and canyons belonging to the Musselshell drainage. The block is cut in two near its east line by Haymaker Creek, a small stream sunk in a canyon 1,000 to 1,500 feet in depth, with sheer sides and rough, bowlder-strewn bottom. The canyon cuts through the main range of the Little Belt Mountains, almost at right angles with its axis, and constitutes a huge gap in the divide between South Fork of Judith River and Musselshell River, tributaries of the two streams named rising within a few feet of each other in the gap.

Mining.—None.

Soil.—Thin, gravelly loam, chiefly comminuted limestone débris.

Agricultural adaptability.—The township contains no arable land.

Grazing capacity.—More than half of the township is grass covered. The grassy tracts lie mostly on the summit of the block and owe their origin to ancient fires and deficient restockage.

Drainage conditions.—The district is remarkably deficient in run-off. The summit of the block is without springs, creeks, or points of seepage, and, with the exception of Haymaker Creek, the various canyons heading in the township are dry during summer and fall.

Towns and settlements.—There are no settlements.

Forest conditions.—On the summit of the block and at the higher elevations the forest consists of thin lines and small stands of subalpine fir and Engelmann spruce separated by grassy glades. On the northern slopes lodgepole pine is the prevailing tree, set in scattered stands—remnants unconsumed by fires. On the southern declivities the forest is mostly composed of red fir, with small proportions of lodgepole pine in the canyons. The timber is short and stocky and chiefly valuable for fuel. Only the southern slopes are accessible for cutting or logging operations.

Cutting.—None.

Burns.—Within recent years the northern and in part the southern areas have been swept by extensive fires, which have destroyed 80 per cent of the timber.

Reproduction.—Scanty throughout. On the burned areas there is no restockage. The subalpine stands are not extending into the ancient fire glades, and in the recent burns on the summit of the block there is a manifest tendency to grass cover rather than to forest.

Undergrowth.—Very light; chiefly trailing juniper scrub.

Litter.—On the burned areas there is a moderate amount of litter; in the green forest there is scarcely any.

Humus.—None.

Classification of lands in T. 11 N., R. 12 E.

	Acres.
Forested	5,800
Nonforested	17,240
Badly burned	4,500
Logged	None.
Agricultural	None.
Grazing	11,740
Bare rocks	1,000

Total stand of timber in T. 11 N., R. 12 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		800,000	800,000
Lodgepole pine	1,000,000	580,000	760,000
Red fir	3,200,000	2,000,000	2,576,000
Subalpine fir		250,000	250,000
Engelmann spruce	4,000,000	4,800,000	5,520,000
Total	8,200,000	8,430,000	9,906,000

Composition of forest in T. 11 N., R. 12 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	10
Lodgepole pine	7
Red fir	35
Subalpine fir	8
Engelmann spruce	40

TOWNSHIP 11 NORTH, RANGE 13 EAST.

Topography.—This township occupies most of the Twin Peak block. In the central areas it comprises a plateau-like region—the summit of the block. The southern portions are cut by many canyons indenting the edge of the plateau and by broken spurs stretching south into the Musselshell drainage. The northern sections are situated on the very steep bold front with which the plateau breaks off to South Fork of Judith basin. The average altitude of the township is 6,600 feet, the summit of the plateau in some places rising to elevations of 7,400 feet.

Mining.—None.

Soil.—Thin, gravelly loam.

Agricultural adaptability.—No arable land.

Grazing capacity.—Most of the township is essentially grazing land, all of the southern slopes and most of the high central ones being covered with grass. Portions of the township, especially the southern sections, have long been used as a range for cattle and sheep.

Drainage conditions.—The canyons are dry through most of the year. There is a small outflow after the spring break-up, lasting a month or two.

Towns and settlements.—None.

Forest conditions.—The forest consists of thin lines and scattered copses of timber on some of the higher slopes and over the summit of the plateau. It is composed of red fir at the lower altitudes and spruce and subalpine fir at the higher. The timber is of value mostly as fuel; it is generally inaccessible.

Cutting.—None.

Burns.—The summit of the plateau area in the central sections of the township has been badly burned within the last eight or ten years. The fires have spread to the northern breaks, and have consumed most of the thin forest.

Reproduction.—Restockage is deficient throughout. The tendency of the burned-over tracts is to become grassed instead of reforested. The wide grassy non-timbered areas on the plateau summit represent ancient fire glades, and exhibit no evidence of again coming under forest cover.

Undergrowth.—Very little.

Litter.—A small amount in the burned-over areas.

Humus.—None.

Classification of lands in T. 11 N., R. 13 E.

	Acres.
Forested	7,000
Nonforested	16,040
Badly burned	4,000
Logged	None.
Agricultural	None
Grazing	11,040
Bare rocks	1,000

Total stand of timber in T. 11 N., R. 13 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		500,000	500,000
Lodgepole pine		100,000	100,000
Red fir	1,000,000	800,000	980,000
Subalpine fir		100,000	100,000
Engelmann spruce	5,000,000	4,000,000	4,900,000
Total	6,000,000	5,500,000	6,580,000

Composition of forest in T. 11 N., R. 13 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	4
Lodgepole pine	1
Red fir	8
Subalpine fir	11
Engelmann spruce	76

TOWNSHIP 12 NORTH, RANGE 9 EAST.

Topography.—The western parts of the district are situated on the summit of the main divide of the Little Belt Mountains, which here is a broad, flat or gently rolling tract, elevated 7,800 feet to 8,000 feet above sea level. The central and eastern areas comprise broad, swelling ridges projecting eastward into the drainage basin of Lost Fork of Judith River and of steep, narrow spurs trending northward into the basin of Middle Fork of Judith River. The canyons of the Middle Fork separating the different spurs are generally narrow and rocky, while those forming the head of Lost Fork, although narrow, have a remarkably long and gradual rise to their heads in the main range in the western part of the township.

Mining.—None.

Soil.—More or less comminuted limestone débris with thin admixtures of loam.

Agricultural adaptability.—The township contains no land suitable for agricultural pursuits, as the altitude is too great.

Grazing capacity.—The township is dotted with grass-covered glades on the summit of the main divide and on the slopes of the canyons. These glades, without exception, mark ancient burns which have become grass covered instead of restocking with forest. Cattle are pastured in them.

Drainage conditions.—The outflow from the township is small and is carried chiefly by Lost Fork, which here is not much larger than a rivulet.

Towns and settlements.—None.

Forest conditions.—The forest is mostly a pole growth, with an intermixing of older trees. At the higher elevations it occurs in scattered copses and thin lines, mostly composed of spruce, limber pine, and subalpine fir. At the lower elevations the northern slopes carry moderately close-set and continuous stands, with red fir as the chief species, while on the southern slopes and bottoms of canyons the stands are sparsely stocked and contain varying percentages of lodgepole pine. The timber has chiefly a fuel value. It is accessible by way of Lost Fork Valley.

Cutting.—None.

Burns.—Badly burned areas occur in the northwest corner of the township in the Middle Fork drainage. The fires probably occurred about five or six years ago.

Reproduction.—The young growth is scanty at the highest elevations, and there are few extensions of the forest into the ancient burns. At the middle and lower elevations the stands are now so fully stocked that further additions are impossible.

Undergrowth.—There is a moderate amount of undergrowth, consisting largely of juniper shrubs.

Litter.—Dead and fallen timber, due to overcrowding, is present in moderate quantities in the close-stocked stands at the lower and middle elevations. In the subalpine forest there is very little litter.

Humus.—The northern slopes have a slight ground cover of moss and pine needles. Elsewhere the humus layer is lacking.

Classification of lands in T. 12 S., R. 9 E.

	Acres.
Forested	16,040
Nonforested	7,000
Badly burned	600
Logged	None.
Agricultural	None.
Grazing	6,000
Bare rocks	400

Total stand of timber in T. 12 N., R. 9 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		600,000	600,000
Lodgepole pine	1,300,000	6,000,000	6,234,000
Red fir	4,000,000	9,000,000	9,720,000
Subalpine fir		350,000	350,000
Engelmann spruce	1,000,000	1,500,000	1,680,000
Total	6,300,000	17,450,000	18,584,000

Composition of forest in T. 12 N., R. 9 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	9
Lodgepole pine	30
Red fir	50
Subalpine fir	1
Engelmann spruce	10
Aspen and cottonwood	Scattered trees.

TOWNSHIP 12 NORTH, RANGE 10 EAST.

Topography.—The township is in the middle and lower portions of Lost Fork of Judith River drainage basin. At the junction of Lost Fork and Middle Fork of Judith River, near the northeast corner of the township, the canyon of Lost Fork is contracted to a narrow gorge between castellated cliffs of limestone. It soon widens, and in its course across the central portion of the township, from west to east, develops a canyon or valley three-fourths mile to 1¼ miles wide. The slopes in the township are mostly steep, and the upper breaks are generally lined with series of limestone cliffs.

Mining.—None.

Soil.—Limestone débris, with thin admixtures of loamy matter.

Agricultural adaptability.—Small meadows and glades in the bottoms of Lost Fork Canyon are tillable. No lands are actually under cultivation.

Grazing capacity.—The pasture areas of the township consist of grassy glades and hillsides in Lost Fork Canyon. They are closely pastured by cattle.

Towns and settlements.—The township contains no towns. In Lost Fork Canyon two ranchers have established themselves. They cultivate no land, apparently holding the tracts for the purpose of controlling the grazing areas of the canyon.

Forest conditions.—The forest consists mostly of red fir of small dimensions, close set on the eastern slopes and thinly stocked on the western. The trees are short and limby from base to summit. Spruce, limber pine, and lodgepole pine are mingled with red fir, particularly in the canyon bottoms and on the summits of the ridges. Near the junction of Lost and Middle forks small proportions of low, scrubby, yellow pine are mixed with the red fir.

Cutting.—Small quantities have been cut in Lost Fork Canyon for farm use.

Burns.—Badly burned areas occur throughout the township. The destruction of the forest on these tracts has been complete. A systematic attempt was made in the summer of 1902 to destroy all the forest in the Lost Fork drainage and incidentally as much more on adjacent areas as would burn. Lost Fork Valley was fired in thousands of places, but owing to sudden showers the fires did not spread.

Reproduction.—Young growth is scanty on the southern slopes throughout the district and also at subalpine heights. There is none on the burned areas. On the northern slopes there is a moderate amount of restockage. In many of the red-fir stands the trees occupy the ground so fully that no further young growth is possible. Red fir is the leading species in the restockage, followed by lodgepole pine. Young growth of yellow pine is very sparse.

Undergrowth.—Juniper scrub and sagebrush form most of the undergrowth. It is small in quantity in the better and more closely stocked stands. On the grassy western slopes bordering Lost Fork Canyon the sagebrush is often very rank and dense.

Litter.—Light except in the burns, where considerable quantities of dead and fallen timber litter the ground.

Humus.—None.

Classification of lands in T. 12 N., R. 10 E.

	Acres.
Forested	13,240
Nonforested	9,800
Badly burned	4,500
Logged	None.
Agricultural	800
Grazing	3,600
Bare rocks	900

Mining. Many mining claims are scattered through the district. With the exception of a group of copper mines near the head of King Creek they are mere prospects. The mines mentioned, although not now in operation, have in former years shipped more or less ore.

Soil. -Thin, gravelly loam.

Agricultural adaptability.—Owing to its general mountainous character the township contains no land suitable for agricultural pursuits.

Grazing capacity. —All of the higher ridges have grassy summits and are available for cattle ranges. No domestic animals are pastured in the district.

Drainage conditions.—The township forms the principal water head of Middle Fork of Judith River, and the outflow is large. The tract contains no lakes or tarns, but is well supplied with springs and creeks.

Towns and settlements.—Only miners' cabins.

Forest conditions.—The western half of the township bears forest composed in part of pure, very close-set stands of mature lodgepole pine averaging 4,000 cubic feet of wood to the acre. In places, chiefly in the creek bottoms, spruce forms over 50 per cent of the total stand, and lodgepole pine is an inconsiderable factor. The stands in which spruce constitutes over 50 per cent represent forest that has not been invaded by fire in the last three hundred years. The higher elevations carry thin and irregular stands of lodgepole pine, limber pine, and subalpine fir. The eastern half of the township is forested with composite stands of red fir and lodgepole pine at the lower elevations on the northern slopes, with red fir, yellow and limber pine on the southern slopes, and with lodgepole pine, in nearly pure-growth stands, on the summits and upper slopes.

Cutting.—Small quantities of timber have been cut by the miners in the district for local use.

Burns.—The northeast corner contains several large burned areas, while smaller tracts, wholly or partly burned over, are scattered throughout the township.

Reproduction.—The close-set stands are fully stocked, and have hardly any young growth. In open stands on the southern slopes seedling and young sapling growths are moderately abundant, and will in time assure a better stockage than the present. The grassy summits of the main divides and higher slopes are ancient fire glades and are capable of bearing forest; into these tracts subalpine species are gradually pushing their way.

Undergrowth. Light, chiefly consisting of juniper scrub.

Litter.— All the close-set stands are choked with immense quantities of fallen timber killed by overcrowding and natural thinning.

Cutting.—The forest along the immediate valley of the South Fork has been culled 10 to 25 per cent.

Burns.—The entire township has been ravaged by fire within the last eight or ten years, and the present stands of forest are mere patches between burned areas.

Reproduction.—The restockage is scanty on the burned-over tracts. Red fir is the chief species in the reforestation.

Undergrowth.—Very light.

Litter.—There is a large accumulation of dead and fallen timber in the burned areas. In the green forest there is a moderate amount of litter.

Humus.—Lacking or very thin.

Classification of lands in T. 12 N., R. 11 E.

	Acres.
Forested	6,040
Nonforested	17,000
Badly burned	13,000
Logged (culled)	2,000
Agricultural	800
Grazing	3,200

Total stand of timber in T. 12 N., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		100,000	100,000
Lodgepole pine		1,800,000	1,800,000
Yellow pine	200,000		36,000
Red fir	5,000,000	8,500,000	9,400,000
Engelmann spruce	1,700,000	1,000,000	1,306,000
Total	6,900,000	11,400,000	12,642,000

Composition of forest in T. 12 N., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	1
Lodgepole pine	10
Yellow pine	.8
Red fir	80
Engelmann spruce	8
Aspen and cottonwood	.2

TOWNSHIP 13 NORTH, RANGE 8 EAST.

Topography.—The western and central portions of this township comprise level and rolling plateau-like tracts—terraces lying in the angle formed by the junction of the main range of the Little Belt Mountains and the Yogo-Porphyry Peak ridge. The terraces border the headwaters of Belt Creek. The eastern portions comprise high ridges belonging to the Yogo ridge system, which in the southern tier of sections swing to the west and culminate in Porphyry Peak at an altitude of 8,000 feet. The mean elevation of the township is about 7,000 feet. The southwest quarter is not included in the forest reserve and the estimates apply only to the 17,280 acres within its boundaries.

Mining.—None.

Soil.—Gravelly loam on the slopes and summits of the higher ridges. Many of the creeks head in swampy areas with deep peaty or boggy soil, while the flat areas of the terraces are usually well covered with loam of moderate depth.

Agricultural adaptability.—Owing to the altitude the weather is too cold and frosty for agricultural pursuits.

Grazing capacity.—Small marshy glades at the head of the larger creeks and two nonforested so-called parks, with an aggregate area of 2,200 acres, afford pasture range. The tracts are but little used.

Drainage conditions.—The run-off from the district is large, and is discharged by way of Belt Creek northward. No tarns or lakelets exist, but springs, bogs, and creeks are numerous. In this township is one of the principal heads of Belt Creek.

Towns and settlements.—None.

Forest conditions.—The forest consists of 99 per cent lodgepole pine. Along the creek occur small proportions of spruce and on the higher ridges subalpine fir and limber pine. The stands are from 80 to 150 years of age, and represent restockage after sweeping fires. There is little mill timber, the larger proportion of the forest being merely a pole growth. The timber is easy of access by way of Belt Creek and its tributaries.

Cutting.—At various times there have been three sawmills in the district, and the timber has been logged off an area approximating 5,000 acres. Most of the lumber has been used in the town and mines of Neihart, a few miles distant; some has been shipped outside to Great Falls and to other localities.

Burns.—Small tracts, altogether 200 or 250 acres, have been burned over in fires of recent years.

Reproduction.—The amount of young growth present is small. The stands are set too close for much seedling restockage to find lodgment. The lodgepole pine stands are chiefly old growth and are slowly giving way to Engelmann spruce; most of the young growth is of the latter species.

Undergrowth.—Light.

Litter.—On the cutting areas the amount of litter left by loggers is large. There also is much dead and fallen timber in the green stands due to overcrowding.

Humus.—Scanty.

Classification of lands in T. 13 N., R. 8 E.

	Acres.
Forested	14,480
Nonforested	2,800
Badly burned	200
Logged, including culled tracts	5,000
Agricultural	None.
Grazing	2,200
Bare rocks	400

Total stand of timber in T. 13 N., R. 8 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		350,000	350,000
Lodgepole pine	12,000,000	35,000,000	37,160,000
Red fir	100,000	250,000	268,000
Subalpine fir		450,000	450,000
Engelmann spruce	3,000,000	4,000,000	4,540,000
Total	15,100,000	40,050,000	42,768,000

Composition of forest in T. 13 N., R. 8 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	0.5
Lodgepole pine	95
Red fir	.1
Subalpine fir	1.4
Engelmann spruce	3

TOWNSHIP 13 NORTH, RANGE 9 EAST.

Topography.—The main topographic features are long spurs trending eastward from one of the main divides in the Little Belt Mountain system—the Yogo-Porphyry Peak ridge—which also forms the western edge of the township. The canyons are deep and narrow, heading with short, steep slopes in the main ridge. The mean altitude of the ridges is nearly 8,000 feet.

spurs which to the north rise to altitudes of 7,000 feet, while to the south they become mere low combs and sink into the rolling foothills of the central sections.

Mining.—Active mining operations are carried on at Sapphire in the eastern areas of the district.

Minerals.—Sapphires.

Soil.—Thin, gravelly loam.

Agricultural adaptability.—Small areas along the canyon bottoms in the central portions of the township are tillable and are used as hay ranches.

Grazing capacity.—The central and eastern divisions of the township are moderately well grassed and have long been used as a range for cattle and sheep.

Drainage conditions.—Scarcely any run-off originates within this township, as the streams flowing through it rise outside its boundaries. The ravines, gullies, and creeks are dry through most of the year. The lower portion of Yogo Creek and South Fork of Judith River flow across the township in the northern and central areas. These streams are of importance on account of the volume they add to the main Judith River.

Towns and settlements.—In the eastern portion, around the sapphire diggings, are a half-dozen buildings for the accommodation of the employees. Sheep shacks are found in the central and eastern areas, while two or three ranch locations occupy the small amount of tillable land in Yogo Canyon.

Forest conditions.—The forest is limited to the western sections. It consists of small-growth red fir and scrubby limber pine fit only for fuel and pole wood.

Woodlands.—The central and eastern areas carry scattered trees and lines and copses of limber pine. The timber has only a fuel value.

Cutting.—The lower slopes of the ridges in the forested areas have been culled and cut over and 60 to 95 per cent of the timber taken. The cutting has been for fuel, mine props, and mill timber.

Burns.—The southeast quarter of the township has been burned over within the last six or seven years and the timber totally destroyed.

Reproduction.—Abundant on northern slopes, deficient elsewhere. The burned-over tracts are not yet restocking. The woodlands are capable of carrying more extensive and better stocked stands, and young growth is slowly extending the timbered areas into the grassed tracts.

Undergrowth.—Underbrush is not abundant. It is chiefly composed of juniper shrubs.

Litter.—Light.

Humus.—None.

Classification of lands in T. 13 N., R. 11 E.

	Acres.
Forested	5,100
Wooded	13,100
Nontimbered	4,840
Badly burned	3,840
Logged	1,200
Agricultural	300
Grazing (woodland)	11,000
Bare rocks	700

Total stand of timber in T. 13 N., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	250,000	3,000,000	3,045,000
Red fir	750,000	2,500,000	2,635,000
Total	1,000,000	5,500,000	5,680,000

Composition of forest in T. 13 N., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	45
Yellow pine	1
Red fir	54

Composition of woodland growth in T. 13 N., R. 11 E., including trees of all species from seedlings up.

	Per cent.
Limber pine	90
Red fir	10

TOWNSHIP 14 NORTH, RANGE 8 EAST.

Topography.—The topographic features of the township comprise a mass of steep, rocky ridges rising to elevations of nearly 9,000 feet and centering in the peak known as Neihart Baldy, just east of the township line. The low relief is formed by many narrow, rocky canyons and by the valley of Belt Creek, which cuts through the district from south to north along its west line.

Mining.—The township was formerly an important mining center, but the low price of silver and possibly the exhaustion of the richer deposits have very much reduced the output, and comparatively little mining is now carried on.

Soil.—Thin loam resting on hard, coarse débris material. Extensive talus slopes, lacking every vestige of loam cover, occur in many places on the steeper slopes.

Agricultural adaptability.—The tract contains no arable land except a few small patches in the canyon of Belt Creek.

Grazing capacity.—A few small glades along Belt Creek and tracts of non-timbered hillsides in different localities constitute the pasture lands of the township. The aggregate acreage is small.

Drainage conditions.—The outflow originating in the district is small. There are numerous creeks, but aside from Belt Creek, which receives them all, none carries a large volume.

Towns and settlements.—There is only one town, Neihart, situated in the canyon of Belt Creek. Formerly a place of considerable importance, owing to its mines, it is now nearly deserted since the larger properties have suspended operations. Numerous miners' cabins are scattered throughout the hills on the different prospects or mines, and more or less extensive developments are in progress in several places. The township contains 4 miles of the Neihart-Great Falls Railroad line.

Forest condition.—The forest consists almost wholly of lodgepole pine, of which 80 per cent represents reforestations after fires which occurred thirty or thirty-five years ago. Near the summit of the ridges are scattered trees of limber pine and red fir, and along the creeks small proportions of spruce.

Cutting.—All of the more accessible areas, with the exception of the head of Carpenter Creek, have been logged and 80 per cent of the merchantable timber taken. The township now contains no mill timber and only inferior dimensions of pole growths. The timber has in part supplied Neihart, and in part has been shipped to Great Falls as smelter poles or to other localities as fuel, mine props, and the like.

Burns.—The northwest quarter of the township has been badly burned in spots here and there within the last five or six years.

Reproduction.—The sapling stands, 30 to 35 years old, are so fully stocked that further additions are impossible. The logged areas are abundantly restocking, but the burns show very little young growth as yet. The restockage in almost every instance is composed of lodgepole pine, though the forest, which the early prospectors burned, was largely composed of red fir. Lodgepole has taken its place and will hold it for the next one hundred and twenty years at least.

Undergrowth.—Light.

Litter.—There is a vast amount of litter throughout the stands. In part it consists of tops of trees and other kinds of woody débris left by the loggers. In part it is the unconsumed remains of fire-killed trees of a former forest.

Humus.—None.

Classification of lands in T. 14 N., R. 8 E.

	Acres.
Forested	15,360
Nonforested	7,680
Badly burned	2,000
Logged	11,000
Agricultural	150
Grazing	1,200
Bare rocks	4,330

Total stand of timber in T. 14 N., R. 8 E.

Species.	Pole and fuel timber.	Total volume of all timber.
	Cubic feet.	*Cubic feet.*
Limber pine	50,000	50,000
Lodgepole pine	2,000,000	2,000,000
Red fir	50,000	50,000
Subalpine fir	20,000	20,000
Engelmann spruce	80,000	80,000
Total	2,200,000	2,200,000

Composition of forest in T. 14 N., R. 8 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Lodgepole pine	99
All other species	1

TOWNSHIP 14 NORTH, RANGE 9 EAST.

Topography.—In the central and western portions is a mass of high, rocky spurs and divides belonging to the Neihart Baldy-Yogo Peak system, reaching elevations of 8,500 to 9,000 feet. The eastern sections comprise a broad basin, forming the head of Dry Wolf Creek, and steep, rocky ridges hemming in the basin on the north and south.

Mining.—Numerous prospect shafts and tunnels occur throughout the township. No active mining operations are carried on.

Minerals.—Silver.

Soil.—Gravelly loam. Most of the township is covered with coarse limestone débris or with detritus derived from the hard eruptive rocks. Thin loam overlies or is mixed with the débris near the surface.

Agricultural adaptability.—A small tract known as Big Park in the central areas of Dry Wolf Creek, near the eastern side of the township, contains a few hundred acres of arable land. None of the land elsewhere is tillable.

Grazing capacity.—The pasture lands consist of small glades and openings in the forest and of the bald summits of the main divides in the central areas. Stock is pastured in Dry Wolf Valley, but not on the high, open ridges.

Drainage conditions.—Despite the altitude of the region the outflow is small. Small springs and rivulets abound near the summits of the higher ridges, but much of the discharge sinks before reaching the main channels. Small quantities of snow remain on the northern slopes near Neihart Baldy during most, if not all, of the summer season.

Towns and settlements.—Two settlers are living on the agricultural lands in the Dry Wolf Creek bottoms, while miners' cabins are scattered through the mineral-bearing central and western tracts of the township.

Forest conditions.—The western portion is stocked with lodgepole pine, in stands of nearly pure growth, 25 to 35 years old. They are reforestations, after fires which occurred about forty years ago. The summit of the main divide in the central areas carries scattered, thin stands of the subalpine type of forest. The timber is low and scrubby, suitable only for fuel, and practically inaccessible. The eastern areas are stocked with stands of lodgepole pine, spruce, and red fir. One-half of this growth is 30 to 35 years old; the remainder is from 100 to 150 years old. Most of this forest grows in blocks, surrounded by extensive burned areas.

Cutting.—The forest has been closely culled in all of the more accessible places in the western and eastern areas. The cut has been largely for the purpose of obtaining smelter poles.

Burns.—A strip, 2 miles wide, along the northern line of the township and a portion of its southeast quarter have been burned over in recent years and the timber totally destroyed.

Reproduction.—On the burned areas restockage is as yet almost wholly wanting. The close-set lodgepole-pine stands in the western areas are so fully stocked that further additions to the growth are impossible. Elsewhere there is a moderate amount of young growth, lodgepole pine prevailing on some tracts, red fir on others.

Undergrowth.—In most places light.

Litter.—There is a large amount of fallen timber in the burned areas and in most of the close-set sapling stands. At high elevations in the green forest litter is light.

Humus.—Northern slopes bear in some places a light moss cover; southern slopes have none.

Classification of lands in T. 14 N., R. 9 E.

	Acres.
Forested	8,960
Nonforested	14,080
Badly burned	7,680
Logged (culled)	3,000
Agricultural	300
Grazing	3,200
Bare rocks	2,900

Total stand of timber in T. 14 N., R. 9 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		100,000	100,000
Lodgepole pine	6,000,000	12,480,000	13,560,000
White-bark pine		400,000	400,000
Red fir	4,800,000	1,200,000	2,064,000
Engelmann spruce	1,800,000	1,000,000	1,324,000
Total	12,600,000	15,180,000	17,448,000

Composition of forest in T. 14 N., R. 9 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	0.5
Lodgepole pine	80
White-bark pine	1
Red fir	15
Subalpine fir	.5
Engelmann spruce	2.5
Aspen and cottonwood	.5

TOWNSHIP 14 NORTH, RANGE 10 EAST.

Topography.—The main topographic feature is a mass of steep ridges with narrow and often precipitous crests, separated by canyons which have no great width.

Mining.—No active mining is carried on at present. Many mineral claims are located in the northern half of the township.

Minerals.—Silver lead ores and specular iron ores.

Soil.—Gravelly loam, with small proportions of loam.

Agricultural adaptability.—There is no arable land.

Grazing capacity.—The township contains numerous small grassy glades and nonforested summits which are utilized to some extent for cattle ranges.

Drainage conditions.—There is a large outflow from the tract, chiefly by way of Running Wolf Creek, which is important in the irrigation of agricultural lands in townships outside the reserve.

Towns and settlements.—The deserted mining village of Yogo is situated in the south-central portion, while miners' cabins are scattered throughout the township.

Forest conditions.—The forest chiefly consists of mixed stands of red fir and spruce. Small quantities of lodgepole pine occur on northern slopes at low and middle elevations. Limber pine forms most of the timber on the crests. The timber is largely a pole growth. In the northeast quarter of the township the stands consist almost wholly of sapling growth 25 to 30 years old. At the lowest elevations yellow pine forms an insignificant proportion of the timber, occupying a narrow belt and disappearing completely a few hundred feet above the canyon levels. The central portions of the district are difficult of access. The southern areas can be reached by way of Yogo Gulch; the northern from Running Wolf Canyon.

Cutting.—The timber has been culled in all the more easily accessible gulches, the cut varying from 10 to 95 per cent.

Burns.—Almost the entire northeast quarter has been burned over. Numerous smaller burns are scattered throughout the remainder of the township.

Reproduction.—Restockage on the burned-over areas is deficient or lacking. There is a moderate amount of young growth in the green forest. Red fir predominates in the restockage.

Undergrowth.—Moderate in quantity; composed chiefly of juniper scrub and *Shepherdia.*

Litter.—There is a large amount of dead and fallen timber on the burned areas. In the green forest the quantity is small.

Humus.—On northern hillsides there is a moss cover 3 to 4 inches in thickness. On southern slopes the humus is either lacking or consists of a very thin layer of pine needles.

Classification of lands in T. 14 N., R. 10 E.

	Acres.
Forested	12,000
Nonforested	11,040
Badly burned	8,900
Logged (cut and culled)	2,000
Agricultural	None.
Grazing	940
Bare rocks	1,200

Total stand of timber in T. 14 N., R. 10 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		400,000	400,000
Lodgepole pine		1,000,000	1,000,000
Yellow pine	300,000	200,000	254,000
Red fir	12,000,000	9,200,000	11,360,000
Engelmann spruce	3,000.000	300,000	840,000
Total	15,300,000	11,100,000	13,854,000

Composition of forest in T. 14 N., R. 10 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	14.7
Lodgepole pine	15
Yellow pine	.3
Red fir	60
Engelmann spruce	10
Aspen and cottonwood	Scattered trees.

TOWNSHIP 14 NORTH, RANGE 11 EAST.

Topography.—Only the western half of this township is in the forest reserve. The region consists of steep fronts of spurs which form portions of the divide between Running Wolf Creek and Yogo Gulch, and attain altitudes of 7,000 feet. The crests are narrow and rocky, while the slopes are deeply scored with narrow ravines and canyons. The portion of the township outside the reserve areas is a ridgy, rolling foothill region.

Mining.—None.

Soil.—Limestone débris with thin admixtures of loam.

Agricultural adaptability.—The lands within the reserve are not suitable for agricultural pursuits owing to their mountainous character. The eastern portion of the township contains more or less agricultural, as well as a large amount of grazing, land.

Grazing capacity.—None.

Drainage conditions.—Scarcely any permanent outflow originates in the district. The central areas are cut by Sage Creek, which has its headwaters in the next township on the west. Most of the canyons and ravines are dry during the greater portion of the year.

Towns and settlements.—None.

Forest conditions.—The forest consists of mixed stands of old-growth red fir, yellow pine, and limber pine, with small proportions of lodgepole pine at the highest elevations. In Sage Creek Canyon the stands are of medium density; elsewhere they are thin. The timber is all third class. It is easy of access in Sage Creek bottoms, but difficult to reach in other localities owing to steep slopes.

Cutting.—On the accessible slopes and in Sage Creek bottoms 60 per cent of the timber suitable for mill use has been cut. The burned ridges and northern declivities of Woodhurst Mountain in the northwest corner of the township in some cases have been totally denuded of their timber by fuel cutters.

Burns.—Large areas in the northwest corner have been totally laid waste by fire within the past five or six years.

Reproduction.—There is a moderate amount of young growth in the living forest. On the burned-over areas the restockage is very scanty or wholly lacking. Red fir is the chief species in the young growth.

Litter.—Abundant both in the green stands and on the burned tracts.

Undergrowth.—Small quantity.

Humus.—None.

Classification of lands in western half of T. 14 N., R. 11 E.

	Acres.
Forested	8,320
Nonforested	3,200
Badly burned	2,600
Logged	4,000
Agricultural	None.
Grazing	None.
Bare rocks	600

Total stand of timber in western half of T. 14 N., R. 11 E.

Species.	Mill timber.	Pole and fuel timber.	Total stand of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	800,000	3,300,000	3,444,000
Yellow pine	2,000,000		360,000
Red fir	8,000,000	6,000,000	7,440,000
Total	10,800,000	9,300,000	11,244,000

Composition of forests in western half of T. 14 N., R. 11 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	40
Lodgepole pine	5
Yellow pine	2
Red fir	53

TOWNSHIP 15 NORTH, RANGE 8 EAST.

Topography.—In the south are steep spurs radiating from the mountain areas around Neihart Baldy, in the center is the valley of Dry Fork of Belt Creek, while on the north are the long slopes and ridges of Barker Mountain. The altitude varies from 6,000 feet for the valley levels to 8,200 feet for the summits of Barker Mountain and the ridges in the southern portion.

Mining.—The tract formerly supported several mining camps. Mining locations abound in the eastern portion.

Minerals.—Chiefly silver, lead, and small quantities of copper.

Soil.—Thin, gravelly loam mixed with much limestone débris.

Agricultural adaptability.—Tracts in the central portion of the township in Dry Fork Valley are suitable for agricultural purposes, and are occupied by farmers. The remainder of the township is not tillable.

Grazing capacity.—Small glades on the southern hillsides and in the canyons. The area of grass land is insignificant.

Drainage conditions.—The run-off originating in the township is small in volume. Most of the lesser creeks are dry during portions of the year.

Towns and settlements.—Two mining villages, Barker and Hughesville, formerly existed in the township but both are now abandoned. Farmsteads are located on the agricultural lands and are occupied continuously.

Forest conditions.—The forest consists of mixed stands of lodgepole pine, red fir, and Engelmann spruce, mostly of small and slender growth, limby and knotty, and fit only for fuel and pole timber.

Cutting.—The forest has been logged throughout, the cut averaging 65 per cent.

Burns.—Extensive fires have devastated the forest in the northern and southwestern portions. Most of the green stands are fire marked. On the burned-over areas all the timber has been killed, but not consumed.

Reproduction.—Restockage is scanty on the larger burns where the slopes face the south. On the northern slopes it is abundant, except on very recent burns, where seedling growth is still lacking. On the cut-over areas the young growth is abundant. Lodgepole pine and red fir compose most of the restockage, the former species prevailing.

Undergrowth.—Light.

Litter.—There is a large amount of litter, consisting of the débris left by loggers and unconsumed by fire.

Humus.—Very light or altogether lacking.

Classification of lands in T. 15 N., R. 8 E.

	Acres.
Forested	14,000
Nonforested	9,040
Badly burned	6,400
Logged	12,000
Agricultural	1,500
Grazing	500
Bare rocks	640

Total stand of timber in T. 15 N., R. 8 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		100,000	100,000
Lodgepole pine	4,000,000	7,800,000	8,520,000
Red fir	500,000	4,300,000	4,390,000
Engelmann spruce	50,000	60,000	69,000
Total	4,550,000	12,260,000	13,079,000

Composition of forest in T. 15 N., R. 8 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	2
Lodgepole pine	58
Red fir	36
Subalpine fir	.3
Engelmann spruce	3.2
Aspen and cottonwood	.5

TOWNSHIP 15 NORTH, RANGE 9 EAST.

Topography.—The general relief of the township consists of moderately steep, high ridges, inclosing broad canyons. The eastern half is intersected by high ridges, radiating in a northerly direction from Yogo and Neihart Baldy and serving as dividing lines between the waters flowing into Judith River basin and Belt Creek. The western half of the township includes valleys and spurs radiating from different centers, such as Mixes Baldy and Barker Mountain. The general elevation is about 7,000 feet.

Soil.—Gravelly loam mixed with more or less finely comminuted limestone débris.

Mining.—Formerly the township was the scene of active mining operations, but since the cessation of work in Barker camp, in the township adjoining on the west, mining has come to a standstill. Numerous prospects and mines [illegible] different stages of development are located throughout the western half.

Minerals.—Various combinations of silver, lead, and copper.

Agricultural adaptability.—Small tracts in the northern portion at the northern foot of Mixes Baldy and on tributaries to Dry Wolf Creek are tillable and in part occupied.

Grazing capacity.—The grazing areas are limited to bare summits on the high ridges in the eastern portion. They are but little pastured, if at all.

Drainage conditions.—The outflow is of moderate volume and is carried in part by Barker Creek and in part by Mill Creek. Both empty into Belt Creek and supply about one-fourth the volume of that stream.

Towns and settlements.—The township contains no villages. There are two or three settlers on the agricultural lands in the northern and eastern areas. A small sawmill is located in the central portions of the district on Mill Creek. Miners' cabins and claims are scattered through the mineral areas.

Forest conditions.—Most of the merchantable forest consists of veteran stands of red fir and Englemann spruce. The lodgepole-pine stands are confined chiefly to the northwest, west-central, and southwest portions, and are mostly composed of sapling growths. At the highest altitudes the forest consists of limber pine, white-bark pine, subalpine fir, and small proportions of spruce. The red fir is of the slender eastern Montana type. The spruce generally is stocky and limby. Most of the timber is comparatively easy of access from the different canyons.

Cutting.—A large amount of timber has been cut. It has been used at Barker mining camp, in the agricultural districts north of this township, and at the copper smelter at Great Falls. Most of the canyon bottoms and their lower slopes have been cut over, the cut varying in different localities from 20 per cent to total.

Burns.—Burned-over areas occur in the northeast and east-central regions. The burns date back ten or fifteen years, and totally denuded the land of its living timber.

Reproduction.—Restockage is deficient on the burned-over areas. It is mostly composed of lodgepole pine instead of the former growth of red fir. In the green stands there is sufficient young growth to maintain the present stockage of the stands. On the logged areas seedling and young sapling growths are abundant, consisting of red fir and spruce in about the same proportions as existed in the former forest.

Litter.—The burns are littered with a great deal of unconsumed débris, in part fallen, in part standing, while on the cutting areas the ground is littered with unpiled masses of tops and limbs. On the logged tracts in the southern areas of the township thousands of smelter poles, mine props, and sawlogs have been cut and left on the skidways and in the forest to rot.

Humus.—At the higher elevations humus is practically lacking. At lower altitudes the forested canyon floors and northern slopes have a cover of moss and pine needles 3 to 4 inches in thickness.

Classification of lands in T. 15 N., R. 9 E.

	Acres.
Forested	15,600
Nonforested	7,440
Badly burned	3,640
Logged	6,800
Agricultural	1,200
Grazing	2,000
Bare rocks	600

Total stand of timber in T. 15 N., R. 9 E.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine		400,000	400,000
Lodgepole pine	13,000,000	8,700,000	11,040,000
Red fir	20,000,000	11,200,000	14,800,000
Subalpine fir		200,000	200,000
Engelmann spruce	5,550,000	2,800,000	3,799,000
Total	38,550,000	23,300,000	30,239,000

Composition of forest in T. 15 N., R. 9 E., including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	5.5
Lodgepole pine	30
White-bark pine	.5
Yellow pine	Scattered trees.
Red fir	52
Subalpine fir	.6
Engelmann spruce	11
Aspen and cottonwood	.4

TOWNSHIP 15 NORTH, RANGE 10 EAST.

Topography.—In the western and southern portions are steep mountain spurs and ridges reaching altitudes of 7,000 feet. The eastern portion is a foothill region, consisting of limestone terraces and basin-like depressions, the terraces rising 250 to 500 feet above the floors of the intersecting ravines and canyons.

Mining.—The tract contains many prospects in various stages of development. No active mining is carried on.

Soil.—Thin, gravelly loam, chiefly limestone débris.

Agricultural adaptability.—The bottom lands in the gulches constitute the agricultural areas. The most important are in North Fork of Spring Gulch, in Dry Wolf Canyon at and below Big Park, and in the different basin-like depressions in the extreme eastern portion of the township. About 500 acres are under cultivation, producing hay.

Grazing capacity.—The east half of the township is largely a grazing area, and is used as such.

Drainage conditions.—The outflow from the district is small in amount. It is discharged by way of the Dry Wolf, a stream which is dry in its lower half during most of the year. The smaller canyons and ravines are dry runs except during and immediately after the spring break-up. There are few springs.

Towns and settlements.—The agricultural lands are settled. There are no towns. Miners' cabins are scattered throughout the mineral-bearing western and southern portions of the tract.

Forest conditions.—The forest consists of mixed stands of lodgepole pine and red fir, with spruce, limber pine, and subalpine fir in the higher canyons and on the upper slope of the ridges. In the eastern areas the stands become thin and scattering and merge into the woodlands. In the northern portion of the township the stands form compact bodies where not invaded by fire within recent years. The timber throughout the district is generally low and scrubby, even in the close-set stands, owing to aridity of the soil and climate. The northern half of the township is easy of access, the southern half moderately so.

Woodlands.—The woodlands are situated mostly in the northeast quarter of the township, covering nearly all of that tract. They are lightly timbered with small stands, copses, and isolated trees of limber pine, red fir, yellow pine, and occasionally lines of small and slender lodgepole pine. The timber has only a fuel and pole value.

Cutting.—All the readily accessible portions of the township have been cut over, the cut varying from 10 to 95 per cent. On some of the burned-over tracts, especially along Dry Wolf and Spring creeks, and between Running Wolf Creek and Woodhurst Mountain, most of the fire-killed timber has long since been cut and removed.

Burns.—Nearly all the western areas of the district have been burned over. The timber on the tracts has been killed, but not consumed, and where not cut is mostly still standing. The fires date back ten to fifteen years.

Reproduction.—Restocking of the burned areas is slowly progressing. On the northern declivities the young growth is mostly red fir, elsewhere lodgepole of the quadrangle are formed by the main axis and the flanking spurs and ridges of the Little Belt Mountains, which strike through the quadrangle from northwest to southeast. The mean elevation is 7,300 feet, the highest points reaching altitudes of 8,200 feet.

The high relief of the central areas is formed by Castle Mountains, a detached outlier of the Little Belt Range, covering only 50,000 acres. Its mean altitude is 7,400 feet, the culminating point of the tract reaching a height of 8,600 feet.

The orographical features of the southern areas are centered in the Crazy Mountains, a rough, rocky, steep tract of country—a southward continuation of Castle Mountains, with which they connect through high, broad, nontimbered ridges. The mean elevation of the region is 7,800 feet, many points in the central portion of the system reaching altitudes of 10,000 feet, while the culminating point of the entire mass is 11,180 feet above sea level.

The lower portion of the quadrangle consists of small tracts of rough and broken foothill region, and of wide, rolling plains and areas of nearly level table and bench lands. The plains are dotted with numerous isolated buttes, intersected with low combs and irregular rocky ridges, and are cut by a multitude of ravines and canyons. The flood valleys are comparatively broad, and are bordered with several tiers of terraces and benches. The mean altitude of the low portion of the quadrangle is 6,000 feet.

DRAINAGE.

The northern part of the region lies partly within the drainage of Judith River and partly within the Musselshell basin. The southern areas drain into Yellowstone River through various small creeks and the larger Shields River. A tract in the west-central regions sends its drainage into the Missouri, in a westerly direction, through Sixteen Mile Creek and Smith River. None of the streams except Shields River carry any considerable volume of water, except during flood times. Outside the mountain areas the streams are not rapid, and meander through valleys of soft alluvial deposits. Most of the outflow originates in the Little Belt ranges. The Crazy Mountains discharge moderate quantities from their northern slopes into the Musselshell. The outflow from the Castle Mountains is small, and the rolling plains region gives rise only to small and intermittent creeks.

AGRICULTURAL LANDS.

The cultivable lands amount to 10.1 per cent of the quadrangle and are so situated as to be easily irrigable. It is not improbable that much of the grazing lands can be reclaimed by means of storage reservoirs and high-line ditches. The lands cultivated at the present time consist wholly of bench lands on the lowest terraces, which can be irrigated from the various streams that course through them without much expense or labor. The soil in the bottom lands varies from a deep, rich loam to a thin topping of alluvial silt on coarse gravel and bowlders. When once under ditch the lands yield good crops of hay and grain. There are no agricultural lands in the mountain areas worth noting.

GRAZING LANDS.

The range lands consist of plains, foothills, and high timberless or sparsely forested mountain areas. The plains have long been used as cattle and sheep ranges; originally covered with luxuriant growths of grass, they have been grazed so closely that where not fenced their grazing value is exceedingly low. Much of the land in the more level plains areas is now owned or leased by private parties and within fence, allowing the grasses a measure of recuperation. The foothill areas have been used very much like the plains and their pasturage value is but little higher. The alpine and subalpine grazing areas are situated above the 7,800-foot contour line. The tracts which are situated within the limits of forest growth represent ancient fire glades where restockage has failed. Above the 10,000-foot level, grassy alpine tracts begin and continue to the highest elevations. Alpine areas occur only in the Crazy Mountains; no point in the Castle or the Little Belt Mountains is higher than timber line, 9,300 feet. The high areas are sheeped wherever accessible except within the limits of Little Belt Mountains Forest Reserve. They are covered with a tough, close sod composed largely of subalpine species of sedge, and have not greatly suffered from the sheeping to which they have been subjected. The grazing lands constitute the class having the largest acreage in the quadrangle, including nearly 51 per cent of the total area.

WOODLANDS.

The woodlands occupy less than 1 per cent of the quadrangle, occurring chiefly on the eastern slope of the Little Belt Mountains where a small tract of foothill country is stocked with broken and intermittent stands characteristic of this class of lands. Red fir, limber pine, and yellow pine thinly scattered in copses and narrow lines or as isolated trees form the growth. The volume of timber which they carry is insignificant, and owing to their proximity to the arid plains no considerable addition to their stockage can be expected.

FOREST.

Generally speaking, all the areas in the quadrangle situated above the 7,000-foot contour and below the 9,300-foot level bear forest, the lands of this class constituting very nearly 40 per cent of the entire area. The growth is almost wholly coniferous, not more than 0.5 per cent belonging to broad-leaved species. The subjoined table exhibits the percentage of each species composing the forest.

Composition of forest in the Little Belt Mountains quadrangle, Montana, including trees of all species with basal diameters of 3 inches and upward.

	Per cent.
Limber pine	3
Lodgepole pine	30
Yellow pine	.1
White-bark pine	.1
Red fir	55
Subalpine fir	1.4
Engelmann spruce	10
Aspen and cottonwood	.4

The forest presents three more or less clearly defined zones or divisions, which present a general uniformity in aspect and composition throughout the quadrangle. In the lowest of these zones, between the 7,000 and the 7,400-foot contours, red fir is the dominant species, limber pine, yellow pine, and lodgepole pine constituting not more than 10 per cent of the growth. Above this zone, and extending to altitudes of 8,300 feet, is the middle division, containing the great mass of the forest. It is made up of lodgepole pine as the dominant species in all the interior and more humid portions of the mountains, with red fir as the leading species on the warmer and drier southern slopes. Associated with these species are varying proportions of Engelmann spruce and limber pine. Above the middle zone subalpine tracts begin. In the stands at this altitude Engelmann spruce forms the larger proportion, subalpine fir and white-bark pine seldom exceeding 20 per cent.

The forest at its lower levels is generally thinly stocked, except in localities where plenty of seepage exists. Its average capacity in timber of all sorts seldom exceeds 1,900 cubic feet per acre. In the middle zone is often a heavy and very close stockage, especially in the lodgepole-pine stands of pure or nearly pure growth, where the yield frequently runs as high as 6,000 to 7,000 cubic feet per acre. The subalpine forest is thinly stocked, and will not average 1,000 cubic feet per acre.

The volume of timber in the quadrangle is shown in the appended table, trees less than 4 inches in basal diameter being excluded from the estimates:

Total stand of timber in the Little Belt Mountains quadrangle.

Species.	Mill timber.	Pole and fuel timber.	Total volume of all timber.
	Feet B. M.	*Cubic feet.*	*Cubic feet.*
Limber pine	4,050,000	20,195,000	20,924,000
Lodgepole pine	159,300,000	398,940,000	427,614,000
Yellow pine	11,800,000	7,400,000	9,524,000
White-bark pine		900,000	900,000
Red fir	287,650,000	613,935,000	665,712,000
Subalpine fir		12,120,000	12,120,000
Engelmann spruce	81,750,000	104,660,000	119,375,000
Aspen and cottonwood		6,000,000	6,000,000
Total	544,550,000	1,164,150,000	1,262,169,000

Extensive fires have swept large areas in the quadrangle during the last thirty-five or forty years. In the aggregate 160,000 acres have been burned over, involving total destruction of the forest. The greatest acreage of burned forest is in the Little Belt Mountains Forest Reserve. Portions of the central areas of the Castle Mountains and of the lower slopes of the Crazy Mountains likewise have suffered severely.

Restockage is abundant throughout the middle and lower zones of the forest, except on the southern slopes, in nearly pure red-fir stands where fire has run. Lodgepole pine leads everywhere in the reforestations. In the subalpine forest reproduction is scanty. When the stands are destroyed by fire at the high elevations a grassy turf takes their place and apparently persists for a century or two.

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

ANNER
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PRELIMINARY REPORT

ON THE

GEOLOGY OF THE ARBUCKLE AND WICHITA MOUNTAINS IN INDIAN TERRITORY AND OKLAHOMA

BY

JOSEPH A. TAFF

WITH

AN APPENDIX ON REPORTED ORE DEPOSITS OF THE WICHITA MOUNTAINS

BY

H. FOSTER BAIN

WASHINGTON
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 6, 1904.

SIR: I transmit herewith the manuscript of a report on the geology of the Arbuckle and Wichita mountains, of Indian Territory and Oklahoma, by J. A. Taff, with an appendix on the reported ore deposits of the Wichita Mountains, by H. F. Bain, and recommend that these reports be published as a professional paper. They are of special interest at the present time in connection with the active search for deposits of precious metals in this region, and contain much valuable information which should be of material assistance to the prospector.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PRELIMINARY REPORT ON THE GEOLOGY OF THE ARBUCKLE AND WICHITA MOUNTAINS.

By Joseph A. Taff.

GEOLOGY OF THE ARBUCKLE MOUNTAINS.

INTRODUCTORY REMARKS.

The Arbuckle Mountains consist of a moderately elevated table-land or plateau in the east-central part of the Chickasaw Nation, Indian Territory. The plateau ranges in elevation from 1,300 feet above sea, in its contracted western part, to 750 feet, at the east end, where it coalesces with the bordering plain.

Geologically the Arbuckle Mountain region consists of a great thickness of rocks, composed chiefly of limestones, which range in age from middle Cambrian to Devonian, and which are succeeded on the borders by an almost equal thickness of Carboniferous conglomerates, shales, and sandstones. In the central part of the district, unconformably beneath the Cambrian strata, there is a mass of granite, granite-porphyry, diabase, and associated crystalline rocks. The uplifting and folding of the region occurred previous to the deposition of the Permian "Red Beds," which were deposited across it on the west. The bearing of the Arbuckle uplift is approximately N. 70° W.

Sixty miles to the northwest are the Wichita Mountains, in southeastern Oklahoma, which are physiographically in marked contrast to the Arbuckle Plateau, being composed of a range of rugged mountains and straggling peaks and hills, set in a practically level plain. The Wichita uplift bears in approximately the same direction as the Arbuckles, N. 70° W. It consists of a central mass of igneous rocks which is partially surrounded, unconformably, by a thick section of Cambrian and Ordovician sandstone and limestone. The stratigraphy is in all essential respects a repetition of that of the Arbuckle uplift, as far as could be determined from the rock exposures. The outline map (fig. 1, p. 12) shows the geographic relations of the Arbuckle and Wichita mountains. Because of the close stratigraphic, lithologic, and structural relations of the two regions discussions of their geology may with propriety be brought together in a single report.

The name Arbuckle Mountains, as used in this report, includes the elevated country involved in the Arbuckle Mountains uplift. The name as it is used locally is applied to the higher western part of the uplift, chiefly west of Washita River. Full exposures of all the older Paleozoic strata which are found in the more elevated western part occur also in the eastern part surrounding a core of igneous rock. Devonian and Carboniferous rocks are involved in the uplift, but lie chiefly in a lower plain bordering the mountainous district. Across the northwestern part of the Arbuckle Mountains are late Carboniferous and Permian strata, which are separated from the older rocks by a great unconformity.

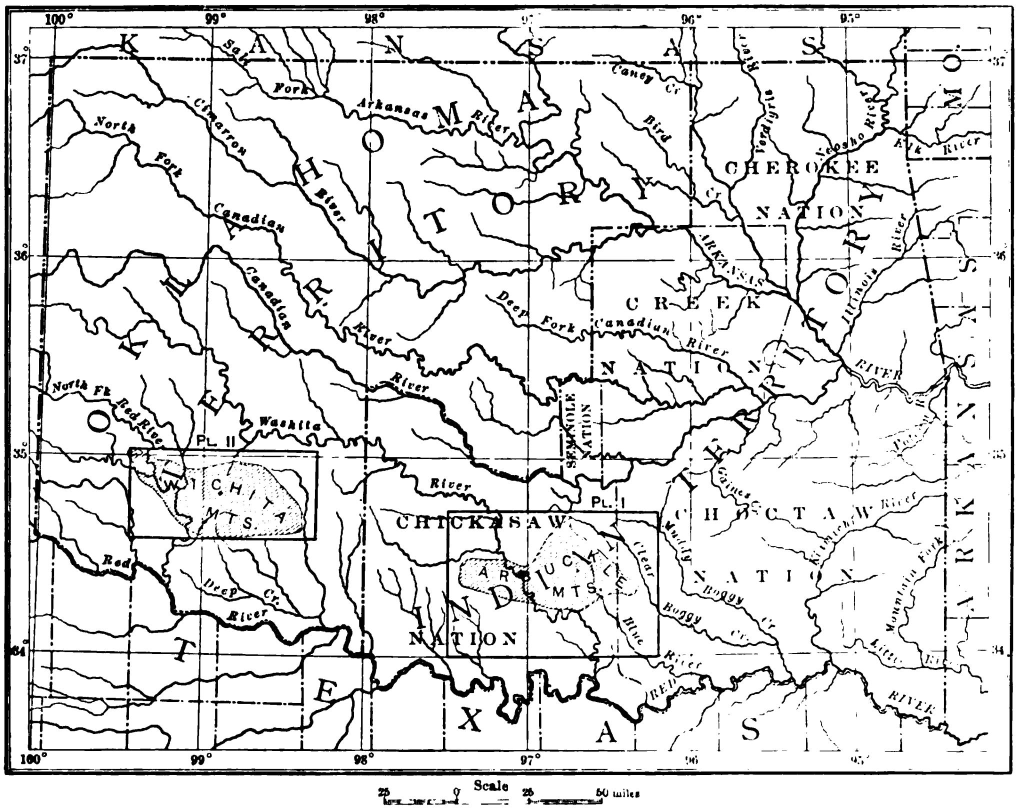


FIG. 1.—Outline map of Indian Territory and Oklahoma Territory, showing locations of Arbuckle and Wichita mountains and boundaries of mapped areas.

Cretaceous strata also lap across the southeastern and southwestern sides of the uplift. A brief discussion of the Carboniferous and Cretaceous geology is also included in this report.

The geology of the Atoka and Tishomingo quadrangles has been studied in detail, and the results have been published in folios 79 and 98 of the Geologic Atlas of the United States. These quadrangles extend from longitude 96° to 97° and from latitude 34° to 34° 30′, and include the eastern and central parts of the

Arbuckle region. The remaining portions of the region, included in the southern half of the Stonewall and the northern three-fourths of the Ardmore quadrangles, have been surveyed in special reconnaissances. In this work the formation boundaries were traversed and mapped, and the rocks have been studied in the light of the classification already established in the survey of the adjoining Tishomingo and Atoka quadrangles.

Dr. G. H. Girty and Mr. E. O. Ulrich collected and studied fossils in cooperation with the stratigraphic work. Without their assistance accurate mapping could not have been accomplished in much of the area.

Large collections of fossils were made from all the limestone formations above the Cambrian. Less abundant faunas occur in the basal Cambrian sandstone, in the Sylvan shale of the Silurian, in the Devonian chert, and in the Carboniferous rocks, yet the fossils are ample for rock classification. These collections are in hand for study preparatory to a monographic report. The classification of the pre-Carboniferous Paleozoic rocks and faunas was made by Mr. Ulrich. Dr. G. B. Richardson and Dr. George I. Adams assisted in the survey of that part of the Arbuckle uplift which is included in the Atoka quadrangle. A large part of the survey of the Tishomingo quadrangle is the work of Mr. Sydney H. Ball.

PHYSIOGRAPHY OF THE ARBUCKLE MOUNTAINS.

GENERAL TOPOGRAPHIC FEATURES.

When considered in a broad sense the Arbuckle Mountain district is coextensive with the area in which rocks older than the Devonian are found. So considered it forms a rudely triangular area approximately 30 miles upon each side, with an arm extending westward from the southwest corner. It is longest from northwest to southwest, which is the general direction of the uplift. The boundaries of the region mark only in part the limits of the uplift. Since the region was uplifted late Carboniferous and Cretaceous rocks have been deposited across it and now conceal the older rocks by unconformable overlap toward the northwest and southeast. The Cretaceous strata upon the southeast dip toward the southeast, and the Carboniferous on the opposite side dip toward the northwest. As erosion progresses these overlapping deposits which once covered the region recede, giving a continually broader section across the uplift. Previous to the deposition of the Cretaceous the older rocks in the region of the uplift were worn down nearly to a flat plain. Since the Cretaceous strata have been removed this plain has been preserved as a low plateau in the harder rocks of the central part of the uplift, while the softer strata upon the sides have been eroded to lower levels. Thus the central part of the uplift which is here termed the Arbuckle Mountain district remains as a low southeastwardly inclined plateau, with distinct escarpments facing northeast and southwest. The western part of the Arbuckle Mountains reaches an elevation of about 1,350 feet and is 400 feet above the plains on each side. The grade of the Arbuckle Plateau toward the southeast is greater than that of the bordering plain. As a result the two plains intersect along the Cretaceous contact on the southeast side. On the northwestern side the thick deposits of Carboniferous conglomerate and "Red Beds" sediments continue away to the northwest, making the broad plain which passes to and around the Wichita Mountains. The descent from the Arbuckle Mountains westward to this plain is inconsiderable. Toward the southeast the Cretaceous plain extends with slight change of grade from the Arbuckle district toward the Gulf coast.

The minor topographic details of the Arbuckle Mountains are due chiefly to the varying resistance of the formations, which has resulted in differential erosion since the removal of the Cretaceous rocks. Bordering the mountains upon the southwest side are five formations extending from the Ordovician to the basal formation of the Carboniferous, which are composed of hard limestones and soft shales steeply upturned and dipping toward the southwest. The Sycamore, Hunton, and Viola limestones, the first, third, and fifth formations, respectively, from above, are hard rocks making level-topped narrow ridges with their crests nearly in the level of the Arbuckle Mountain plain. Between these limestone ridges the softer Woodford chert of the Devonian and the Sylvan shales of the Silurian outcrop in wooded valleys. On the northeastern side of the district are similar ridges made by the same formations, excepting the Sycamore limestone. Between these belts of alternating ridges and valleys and toward the axial part of the uplift the broad plateau proper of the Arbuckle Mountains is chiefly in the truncated edges of the Cambro-Ordovician limestone and the reduced pre-Cambrian granite and porphyry. In the more elevated part of the uplift the small streams, because of their steep grades, have etched the border of the plateau into a frill of deep, short gulches. This border erosion is especially marked near the gorge of Washita River where it crosses the Arbuckle Mountains. Washita River was, without doubt, imposed upon the rocks of the Arbuckle Mountains from a former position in strata which are now removed. The explanation of this river erosion in the Arbuckle Mountains as a part of the physiographic history of the uplift will be discussed below.

HISTORY OF THE PHYSIOGRAPHIC FEATURES.

In the Arbuckle Mountains the rocks from the middle Cambrian, the lowest known in the region, up to middle Carboniferous, which were formed previous to and are involved in the uplift, are well exposed. The general physiographic history is learned from the extensive Coal Measures conglomerate in the northwest and southwest sides of the region, the later "Red Beds" conglomerate across the west end, and the Cretaceous sediments across the southeastern side of the uplift. Only a brief discussion of this history can be given in this paper.

From Cambrian time up to middle Carboniferous the stratigraphic succession is regularly conformable, showing that the rock beds remained practically flat during successive periods. There were probably oscillations which brought the sediments to the surface of the water at times, and gave occasion for slight erosion, which will be described in the discussion of the stratigraphy. About the middle of the Carboniferous period, near the beginning of Mississippian time, the rocks of the Arbuckle Mountain region were uplifted and folded, and mountainous conditions resulted. During and following the uplift and before the end of Carboniferous time the mountains, so far as can be observed, were worn down to moderate relief. During this time thick deposits of limestone conglomerates, derived from the Silurian, Ordovician, and Cambrian rocks toward the heart of the uplift, were laid down in the bordering Carboniferous seas. As erosion progressed, during late Carboniferous time folding and faulting occurred, as is shown by the infolding and faulting of some of the earlier Carboniferous conglomerates with older Paleozoic strata. Remnants of this Carboniferous conglomerate occur in the present Arbuckle Plateau in a number of places and conceal the whole northwestern extension of the uplift. The nearly flat limestone conglomerate, grits, and clays of the basal portion of the "Red Beds" rest unconformably upon the Coal Measures conglomerate and across the extreme western end of the Arbuckle Mountains. Between the Permian and the Cretaceous there is no record of sedimentation, and it is presumed that land conditions prevailed.

Development of the Arbuckle Plateau.—The basal formation of the lower Cretaceous lies across the southeastern side of the Arbuckle uplift, on a nearly smooth floor, composed of granite and interstratified with thick and hard limestone and thinner limestone, sandstone, and shale formations. This formation, which is slightly inclined toward the southeast, is composed of the beach and near-shore deposits of the Cretaceous sea, which transgressed northward and most likely beyond the region of the Arbuckle Mountains. The nature of these deposits of the Cretaceous and of the flat floor upon which they rest suggests strongly that the land upon which the Cretaceous sea advanced had been reduced to a low peneplain. Whatever the condition of the pre-Cretaceous land, it appears that the Cretaceous degradation reduced all the rocks from the soft shales of the Carboniferous to the massive hard limestones of the Cambro-Ordovician and the granite to a nearly flat plain. The basal Cretaceous formation was rapidly eroded toward the south, in the direction of the drainage and of the dip of the strata. After these sands were removed from the rock floor of varying hardness on which they had been deposited, differential erosion produced the topographic forms of the Arbuckle Mountains and the bordering parallel hills and valleys and etched plateau. The plain of the Arbuckle Mountains when projected southward passes beneath the Cretaceous sediments, approximately in the Cretaceous floor.

As the soft Cretaceous rocks above the Arbuckle uplift were removed the streams which flowed in them without obstruction toward the south descended and were imposed upon the hard rocks of the Cretaceous floor. Thus Mill and Pennington creeks and Blue and Washita rivers were imposed upon the Arbuckle Mountains. As Mill and Pennington creeks and Blue River are near the eastern end of the uplift from which the Cretaceous was last removed, and do not flow beyond the limits of the Arbuckle Plateau, they have wide, shallow valleys, extending southward in Paleozoic and Cretaceous strata with very slight increase in grade. Washita River, however, flows in a lower plain for long distances in the soft rocks before reaching and after its passage through the Arbuckle Mountains. These soft rocks were worn down more rapidly than the hard limestones, and the river was required to keep pace in cutting its deep and narrow gorge across the Arbuckle Mountains.

Peneplain of probable Tertiary age.—Toward the northeast and southwest there is a descent of 100 to 400 feet from the plateau in the Arbuckle Mountains to the general level of the plain formed upon the softer Carboniferous rocks. The erosion which produced this lower plain has uncovered and obliterated a large part of the marine Cretaceous plain northeast and southwest of the Arbuckle district. Southeastward, in the general direction of the drainage toward the Gulf of Mexico, this plain descends approximately with the grade of the rivers. Along these river valleys there are elevated remnants of old channels slightly below the level of the plain. They contain deposits of gravel and sand, similar to the material transported by the river at the present time.

These deposits occur upon the worn surfaces of Carboniferous, Cretaceous, and early Tertiary rocks. Upon approaching the Tertiary border in southwestern Arkansas and eastern Texas these gravel deposits become more abundant and finally come to an end or descend beneath latest Tertiary deposits bordering the Gulf coast. Farther toward the northeast these elevated shallow and wide river channels lying nearly in the peneplain have been studied and mapped, along Canadian and Arkansas rivers, from the western border of the Creek Nation to the Arkansas line in Indian Territory. This peneplain stretches westward into Oklahoma and northward across Indian Territory. It has a lower inclination toward the southeast than the marine Cretaceous plain represented in the Arbuckle Plateau. Northward the horizon of the latter plain projects above the land, while the former continues nearly flat and is now preserved throughout southern and central Indian Territory in almost innumerable level-crested ridges and hills. These ridges and hills are supported usually by beds of hard rock, and their crests occur at elevations approximating 850 feet. Outside the mountainous regions there are few hills which rise above this general level. These are usually table-like and are protected by flat and hard strata.

In the eastern part of Indian Territory the Ouachita Mountains rise above this plain, as do also certain isolated mountains in Arkansas Valley. In the Ouachita Mountains this peneplain is represented by wide, flat valleys which have been produced upon the softer rocks. In Arkansas Valley the mountains which rise above the plain are limited areas where the rocks occur in broad, synclinal folds containing the harder and thicker sandstone strata. These mountains rise above the plain, as monadnock-like eminences and peaks, to elevations of 1,700 to 2,500 feet above the sea. The wide distribution of the surficial deposits connected with old river channels, but slightly depressed below the peneplain, their relations to the more abundant gravel deposits near the Tertiary, as already described, and the widespread degradation of the hard and soft rocks to the same general level support the hypothesis that the surface nearly reached sea level at the time of its reduction to the peneplain stage.

Recent peneplanation in the broad valleys.—It would appear that since the formation of the probable Tertiary peneplain the land has been tilted slightly toward the southeast. In support of this it is observed that the larger streams have descended in softer strata to depths approximating 200 feet below the general level of the Tertiary peneplain, cutting for themselves wide and flat valleys. These wide valleys may be considered to form rudely a lower peneplain representing the present stage of erosion. The smaller streams tributary to the large creeks and rivers have steeper grades, especially toward their sources, and occupy various levels between two peneplains.

STRATIGRAPHY OF THE ARBUCKLE MOUNTAINS.

IGNEOUS ROCKS (PRE-CAMBRIAN).

Igneous rocks are exposed in three areas in the Arbuckle uplift. The largest of these in the eastern portion is composed, for the most part, of granite, of a small amount of rocks related to granite, and of intrusive dike rocks, chiefly diabase. The other two areas, which are situated near each other in the western part of the mountains, are composed of granite-porphyry and aporhyolite, containing also basic dikes. The granite occurs in the extreme southeastern side and is partially concealed by the lower Cretaceous sediments which lie across this portion of the Arbuckle region. It occurs in a rudely triangular area about 20 miles in length and 10 miles in width at its broadest part, near the western end. It is overlain across the western end and at a few points upon the northern side by middle Cambrian, the oldest stratified rocks of the region. Throughout the northern side, with two exceptions, the granite comes in contact with the sedimentary rocks along lines of faulting.

The two porphyry areas occur in the Arbuckle Mountains proper, near the western part of the uplift. Like the granite, the porphyry upon the western and southwestern sides is overlain by the middle Cambrian sediments, and upon the eastern and northeastern sides it comes in contact with the sedimentary rocks along lines of faulting.

In middle Cambrian time the granites, porphyries, and other associated or included igneous rocks were eroded and their materials deposited as the oldest Cambrian sediments, which here rest on them. Their approximate age, however, can not be determined further than is indicated by their position beneath middle Cambrian rocks.

GRANITE AND ASSOCIATED IGNEOUS ROCKS.

The granite is a reddish or pinkish rock moderately coarse in texture. Associated with it are numerous dikes of gray to dark-blue or black basic rock, besides less numerous dikes of pale-pink to white aplite, and rarely dikes of granite-porphyry. These dikes of basic rock penetrate the granite in many directions, though the largest number have a bearing generally toward the northwest and southeast. The surface of the granite is nearly flat and is in large measure concealed by materials resulting from its own disintegration and by residual sands from the Trinity formation, so that it is not possible to locate or trace many of the dikes beyond the immediate valleys of the streams where the rocks have their best exposures. In the eastern part of the area the basic dikes are few in number, though the granite is usually so concealed by surficial deposits that satisfactory observations could not be made. Toward the west these dikes increase in number, until in the vicinity of Tishomingo they are of such frequent occurrence and have increased in size so greatly as to form a considerable part of the igneous mass. In this part of the area they range from thin stringers to dikes 40 feet in thickness.

Quartz-monzonite has been found to occur in association with and apparently as phases of the granite. In some places it has a well-defined boundary, while at others it seems to grade into the granite.

Usually the exposures of the granite are such that its true relation to the aplite was not accurately determined. In certain fresh exposures the aplite occurs as dikes or stringers penetrating the granite. They are usually but a few feet thick, and were not found in association with the basic dikes.

The granite-porphyry was found in but two places. It occurs in granite, in distinctly defined bands, 20 feet wide, trending toward each other. It is probable that they belong to the same dike. The granite-porphyry is cut by a basic dike which passes also into the ordinary pink granite. The granites and associated igneous rocks in the Arbuckle region have been studied by Mr. Ernest Howe, of the United States Geological Survey, and the petrographic descriptions of the igneous rocks are from Mr. Howe's report.

Granite.—The typical granite is in general a biotite-granite, rich in microcline and poor in ferromagnesian silicates. Associated with the granite are pegmatite veins, which contain the same minerals as the granites, but in coarser aggregates. The feldspars are principally orthoclase or microcline, with plagioclase, albite, and oligoclase almost always associated. Titanite, which occurs in extremely perfect crystals, is, under the microscope, a noteworthy constituent. Garnet, also, occurs in some specimens as an important accessory mineral.

Quartz-monzonite.—Quartz-monzonites are associated with the granite and occur apparently as phases of it. As far as observations could be made, monzonites occur in small areas. In most places where this rock was noted the exposures are poor and the relations of the rocks could not be satisfactorily determined. In all the specimens examined petrographically, plagioclase, ranging in composition from oligoclase to labradorite, is almost as prominent as orthoclase or microcline; quartz, usually in the form of pegmatitic intergrowths, with orthoclase, is always present, but never in abundance. With these minerals biotite occurs almost invariably; in all but two of the specimens hornblende is abundant. One of the rocks contains hornblende equal in amount to the plagioclase and alkali feldspar, and is remarkable in its very considerable development of quartz. It is a middle type between granite and diorite. From this intermediate type the tendency seems in the majority of cases to lean toward the side of the granites. One of the specimens is a nearly pure diorite, consisting largely of plagioclase, feldspar, and hornblende, with a very little alkali feldspar and quartz. These rocks indicate a very interesting series, worthy of more extended study.

Aplite.—Aplite occurs also in association with the granite in a manner similar to that of the diabase. In places the exposures are such that the true relations between the aplite and the granite could not be determined. Where erosion had removed the disintegrated rock the aplite appears as well-defined dikes. Specimens examined petrographically are pale pink or nearly white in color, containing no ferromagnesian silicates, and composed almost entirely of feldspars and quartz, with very little magnetite or hematite. The texture of the aplites is even and finely granular. Orthoclase, microcline, and plagioclase are present in all and are slightly greater than quartz in amount.

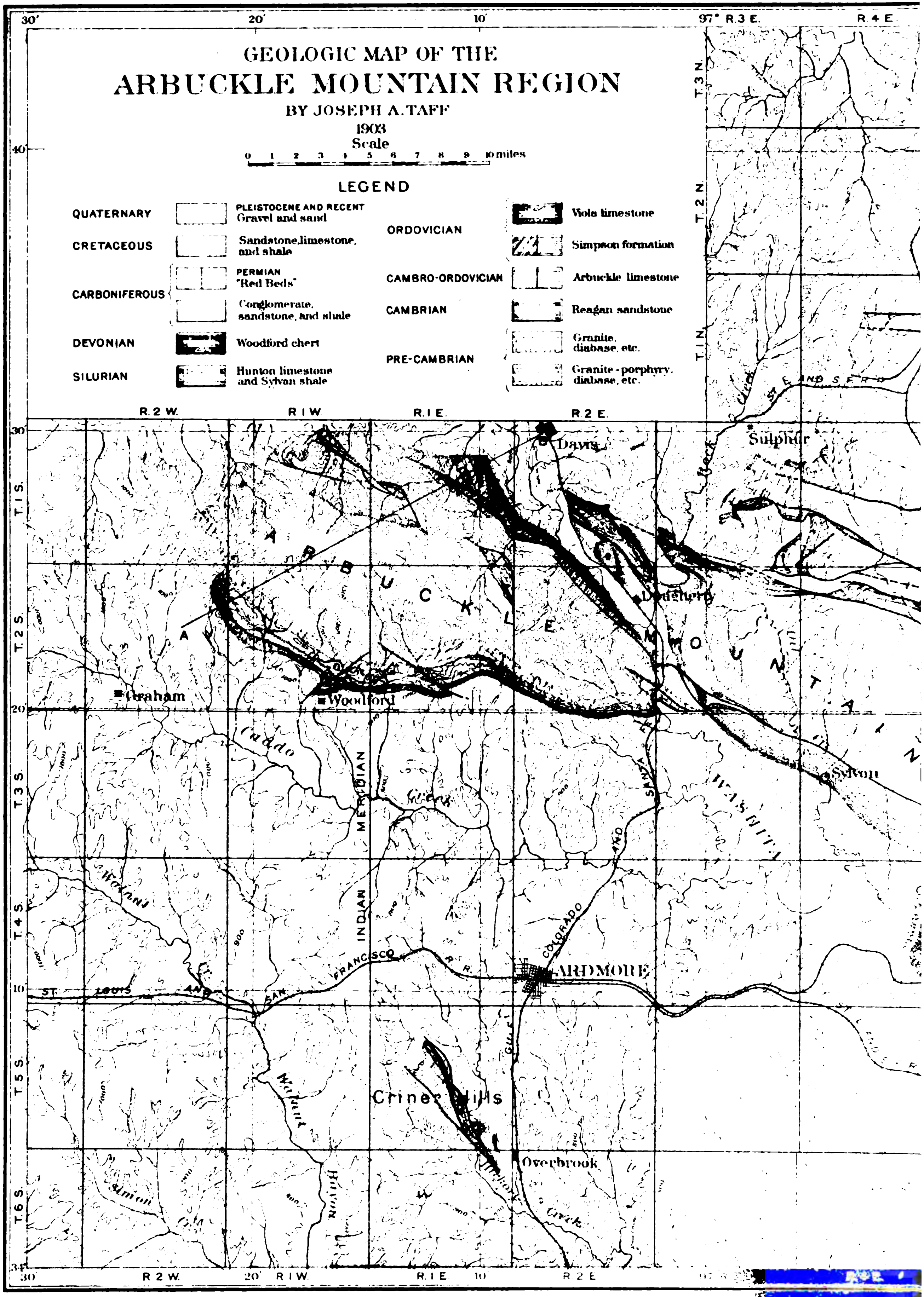
Granite-porphyry.—Granite-porphyry occurs in well-defined bands, apparently as dikes in the common granite. The only exposure of this porphyry noted is in a small tributary of Rock Creek in the western side of sec. 1, T. 4 S., R. 5 E. The granite-porphyries are fine. textured and brick red. The phenocrysts, distributed in a dense groundmass, are irregular in size and consist of orthoclase, quartz, and some dark silicates, probably hornblende, which is now completely altered to chlorite and the hydrous oxides of iron. The feldspars and what remains of the ferromagnesian silicates are in large imperfect crystals, while the quartz is in very much smaller, rounded and dihexagonal grains. The groundmass is partly a finely granular aggregate of quartz and feldspar and partly a micropegmatitic intergrowth of these two minerals. Magnetite is an abundant accessory.

Diabase dikes.—Dikes of diabase are common throughout the granite, but increase in abundance from east to west. Near the western end of the granite, in the mass northwest of Tishomingo, they are so numerous as to form in places a network of sheets and stringers. These dike rocks have considerable variation in texture, but are all to be considered as diabase. They vary from dense, finely porphyritic contact facies to coarse rocks which might almost be considered gabbro. Their composition is very uniform. Augite, labradorite, and magnetite are always present; biotite rarely occurs; and in only one instance was olivine found, or, more correctly, pseudomorphs of serpentine after olivine. These diabase dikes usually weather more rapidly than the granite, and as a result fresh specimens in many cases can not be obtained. The secondary minerals chlorite, kaolin, calcite, muscovite, and epidote—are very abundant. In the dense rocks, evidently near the contacts, the groundmass, although very fine grained, is still distinctly ophitic. Delicate skeleton crystals of magnetite add materially to the felt-like appearance. Phenocrysts are seldom perfect and never large. The plagioclase laths average about one millimeter in length. The coarser specimens, probably from the central portions of large dikes, show a tendency to assume a granular structure, which, however, is never perfect; their structure would still be described as ophitic.

PORPHYRY AND ASSOCIATED BASIC DIKES.

The porphyry of the Arbuckle Mountains occurs in two areas, known as the East and West Wooded Hills, which rise slightly above the general level of the Arbuckle Mountain table-land. These igneous masses have the same relations to the surrounding stratified rocks as the granite above described. The relations are graphically shown on the geologic map (Pl. I). These igneous rocks, of pre-Cambrian age, consist of granite-porphyry and aporhyolite of various shades of pink, red, and brown. In so far as could be determined by a general survey the aporhyolite is intrusive through the granite-porphyry. In places the aporhyolite, like the granite-porphyry, is strongly porphyritic and shows large clearly defined phenocrysts of pink feldspar in a reddish and darker fine ground

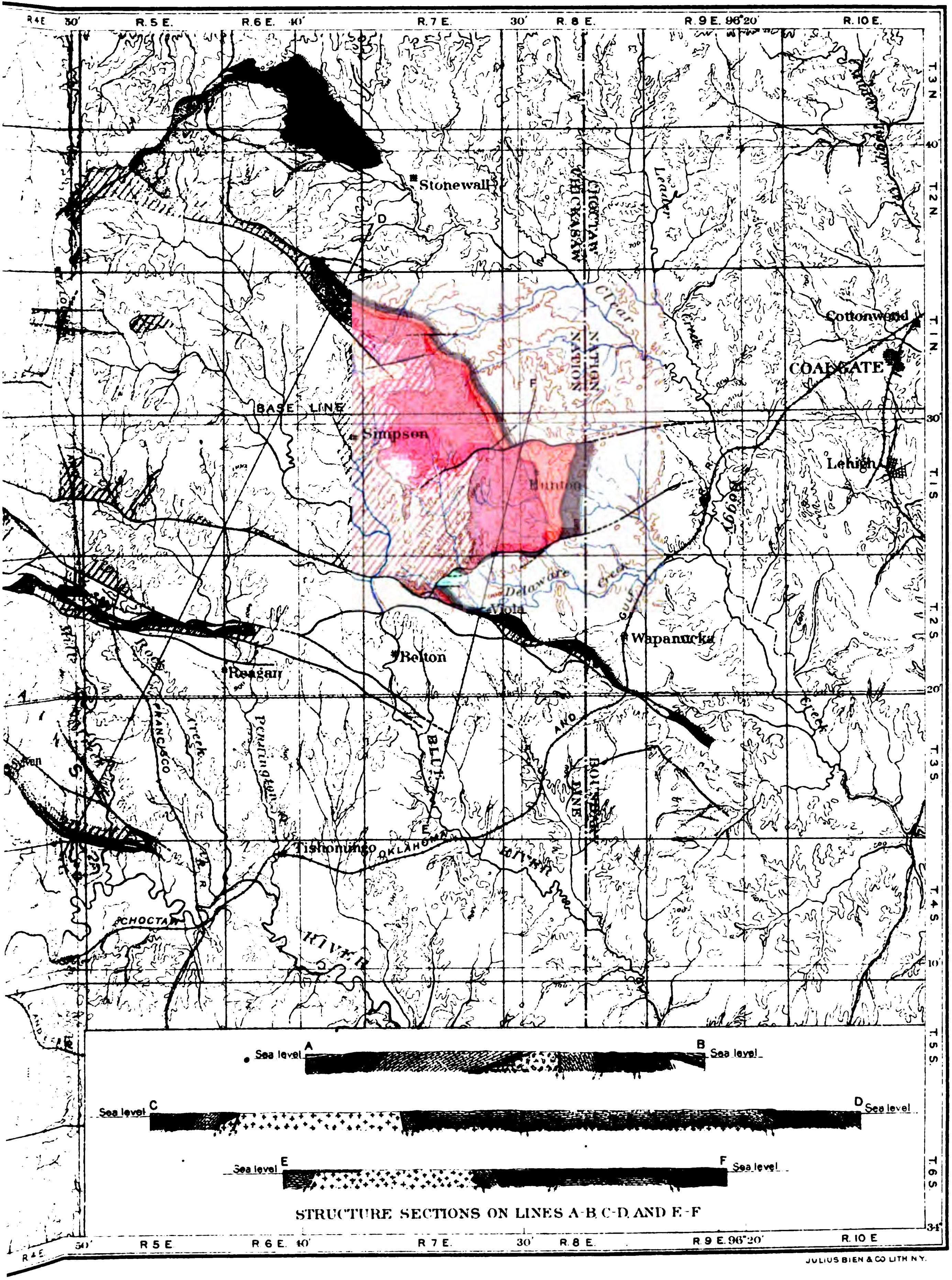
U.S. GEOLOGICAL SURVEY



GEOLOGIC MAP OF THE ARBUCKLE MOUNTAIN REGION

BY JOSEPH A. TAFF

1903



STRUCTURE SECTIONS ON LINES A-B, C-D, AND E-F

JULIUS BIEN & CO. LITH. N.Y.

mass. In other places it is even textured, without porphyritic character, and shows a beautifully banded structure. In thin sections a fluidal, vesicular structure is shown. The base is generally devitrified, but certain bands show perlitic structure.

Like the granite in the eastern part of the uplift, the igneous mass is penetrated by numerous dikes of diabase, which are themselves older than the middle Cambrian, since sediments of that age rest uncomformably upon them. These dike rocks vary somewhat in character and in color, from very dark blue to gray, but in general are of the same nature as those occurring in the granite area.

SEDIMENTARY ROCKS.

In pre-Cambrian time the region of the Arbuckle uplift was submerged and the Reagan sandstone, the lowest Cambrian sediment, was laid down upon the eroded surface of the granite and porphyry as a beach and off-shore deposit. The pre-Cambrian land, composed of igneous rocks, possessed some relief at the time of the submergence, as is shown by the uneven contact of the igneous rocks with the Reagan sandstone and also by the variable nature of the sandy deposits. The land in the immediate vicinity of the uplift was soon submerged, however, as is shown by the presence of fossiliferous horizons representing the same mid-Cambrian time in the upper member of the Reagan sandstone wherever it is exposed.

CAMBRIAN ROCKS.

Reagan sandstone.—This sandstone is a variable formation, as regards both its thickness and the nature of its materials. In the eastern part of the uplift, in contact with the granite, it varies in thickness from a few thin beds to approximately 500 feet, with an average thickness of about 300 feet. In its thickest portion, at the western end of the granite, the lowest beds are composed for the most part of coarse arkose grit. The following is a record of the thickest section of the Reagan sandstone as it occurs at the western end of the granite area, beginning at the base:

Section of Reagan sandstone.

	Feet.
Quartzite and arkose conglomerate, composed of poorly sorted granitic materials	30
Coarse grit and sand, with some clay and green sand in upper part, generally well stratified	370
Thin-bedded and laminated sandstone, becoming calcareous in the upper part	60

This section is followed by generally thin-bedded siliceous limestone and shaly strata through several hundred feet to the top of the middle Cambrian. The calcareous beds at the top and above the Reagan contain numerous fossils of well-defined middle Cambrian forms.

The Reagan sandstone overlying the porphyry in the southern sides of the East and West Wooded Hills has a section similar to that in contact with the granite. The coarse materials which make lentils of conglomerate near the base, however, are here composed of porphyry and associated dike rock. In the upper part of the formation greenish clays are probably more abundant, and the green sand continues higher up into the more calcareous beds. As in the occurrence near the granite, here the calcareous rocks contain numerous middle Cambrian fossils.

CAMBRO-ORDOVICIAN ROCKS.

Arbuckle limestone.—The Arbuckle limestone, with the exception of thin, shaly strata and occasional siliceous and cherty beds, is composed entirely of light-blue and white limestone and cream-colored to white crystalline dolomite. The section ranges in thickness from 4,000 to 6,000 feet, and includes the whole of the upper Cambrian and the Calciferous of the Ordovician. From the base of the formation upward to the top of the middle Cambrian the rocks are composed of thin-bedded and, in part, intraformational conglomerate and shaly limestones. While pursuing stratigraphic field work in connection with the study and collection of the fossils, Mr. E. O. Ulrich noted the occurrence of what appeared to be shaly lentils at the top of the middle Cambrian, indicating to his mind an unconformity between the upper and lower Cambrian.

Beginning with the upper Cambrian the rocks are composed of massive and hard, pink to yellow crystalline limestone and dolomite, which weather to various shades of brown and almost black. Rocks of this character have a thickness of 500 to 600 feet, and are followed by lighter-colored massive dolomite and limestone, without any indication of time interval, up into the Ordovician. Beginning approximately 450 feet below the top of the Arbuckle formation the limestones become more thinly bedded and are associated with thin and, in places, shaly strata. Very near the top occasional sandy beds occur.

In the massive beds in the central part of the formation fossils are found, but not in great abundance. Near the top, however, where the rocks become argillaceous, fossils are more common. Fossils of the following genera, mostly undescribed, occur in the upper 1,250 feet of the Arbuckle limestone.

Fossils of upper portion of Arbuckle limestone.

Billingsella, 2 species.
Polytoechia?
Stromatocerium.
Calathium, 2 species.
Maclurea.
Ophileta.
Eccyliomphalus.
Eccyliopterus.
Raphistomina.
Leiospira (? Helicotoma).
Euconia (near E. ramsayi Billings).
Hormotoma, 2 species, one very near H. artemesia Billings.
Trochonema.
Orthoceras.
Trochoceras.
Leperditia.
Isochilina.
Primitia.
Bathyurus.
Isotelus canalis?

On account of its thickness and its position the central part of the uplift of the Arbuckle formation, though generally steeply upturned, occurs over broad areas, and forms a large part of the table-land of the Arbuckle Mountains. It extends from the southeastern end of the Arbuckle Mountains, where it is overlapped and concealed by Cretaceous strata, to the northwestern end, where it passes beneath Pennsylvanian and "Red Beds" conglomerates.

ORDOVICIAN ROCKS.

Simpson formation.—After the Arbuckle limestone was deposited there was a general change in the nature of the sediments. The top of the limestone seems to have been slightly eroded locally and upon the surface were deposited beds of pure sand. At other places the Arbuckle limestone is overlain by shaly and impure lime—the basal beds of the Simpson formation. On these local sandy beds at the base there were deposited greenish shales and thin crystalline and shelly limestones interstratified with a number of beds of sandstone, making a total thickness ranging from about 1,200 to 2,000 feet. Following is a general section of the Simpson formation on the south side of the Arbuckle uplift west of Washita River, the beds being given from above downward.

Section of Simpson formation on south side of Arbuckle uplift, west of Washita River.

		Feet.
1.	Thin limestone with green shales interstratified	400
	In the lower part the limestone is subcrystalline, resembling beds lower in the formation, while higher it becomes fine grained and argillaceous, resembling that of the succeeding Viola formation.	
2.	Sandstone	90
3.	Limestones and shales interbedded	400
	Some of the limestones are highly fossiliferous: *Orthis tricenaria*, *O. deflecta*, *Monticuliporoid* Bryozoa, highly ornamented cystid plates, and species of *Ctenodonta*.	
4.	Sandstone	100–200
5.	Shaly limestone	195
	The lower 50 feet highly fossiliferous, containing Ostracoda with numerous Bryozoa and bases of crinoid columns, making a fauna sufficiently peculiar to be easily distinguished.	
6.	Sandstone	33
7.	Thin-bedded limestone and shales interstratified	295
	Contains fossils in great abundance, chiefly Ostracoda of large and small species, and numerous gasteropods, pelecypods, brachiopods, and trilobites.	
8.	Greenish shales with few thin limestone layers	245
	Thin sandstone.	
9.	Granular crystalline limestone in thin beds	350
	Contains an abundance of Ostracoda (*Leperditia* chiefly) and other fossils so rare as to appear wanting.	
10.	Thin limestone and shales interstratified with occasional thin sandstone	29
11.	White to light-brown sandstone, occurring locally	0–100

The sandstone bed No. 4 in the section is more persistent in its characteristics, including thickness, than the others, and serves as a convenient datum for reference. It also separates the formation into two divisions of nearly equal thickness.

In the northern portion of the region, and especially on the northern side of the Arbuckle Mountains west of Washita River, the Simpson formation is found to be much thinner than in the southern portion. This is due chiefly to the absence of the lowest beds, which have an aggregate thickness of several hundred feet. The upper division of the formation is found to become thinner northward, owing to the decrease in the quantity of lime and clay. With the decrease in amounts of lime and clay northward there is a general increase in the abundance of sand, the whole formation becoming more siliceous.

On the northern side of the region the Simpson formation is exposed much farther east than on the southern side, where it is found in its typical thickness and consistency. Near the east end, in the valleys of Blue River and Delaware Creek, the structure is so variable that accurate estimates of thickness could not be made. It is approximately 1,200 feet thick, and the sand is relatively more abundant than in the northern part of the Arbuckle Mountains farther west. In all places noted the sand is fine grained, and in many cases is completely separated from clay and lime sediments.

The Simpson formation contains a very abundant fauna. Large collections of fossils were made by Mr. Ulrich, especially from the district west of Washita River. Only a preliminary study of this fauna has been made, but it is sufficient for accurate classification and general correlation. Below are lists of readily recognized forms, separated according to the two divisions of the formation.

Fossils of lower Simpson formation.

Plates of cystidian (? Glyptocystites).
Siphonotreta sp. undetermined.
Crania sp. nov.
Orthis costata.
Orthis (Dalmanella) pogonipensis Walcott.
Orthis sp.? nov. (near holstoni Safford).
Ctenodonta sp. nov. (of C. nasuta type).
Ctenodonta sp. nov. (large, ovate species).
Cyrtodonta sp. undetermined.
Modiolopsis sp. nov.
Modiolopsis sp. nov.
Bucania sp. undet. (small, with flat dorsum).
Bucania sp. undet. (larger, with subcarinate dorsum).
Bucanella sp. undetermined.
Maclurea sp. undetermined.
Eccyliopterus sp. undetermined.
Leperditia sp. near fabulites.
Leperditia bivia White.
Leperditella of several undetermined species. This division is particularly characterized by these Ostracoda, many of the limestone layers being crowded with large and small species.
Bathyurus sp. undetermined.
Ceraurus of two undetermined species.
Amphion nevadensis? Walcott.

Fossils of upper Simpson formation.

[Most of these species known only in the upper 300 feet. Those occurring also in the lower part of the subdivision are distinguished by an asterisk.]

Receptaculites sp. nov.
Protarea sp. nov. (massive-laminar form).
Archæocrinus sp. undetermined.
Platycystites (?) sp. nov.
Amygdalocystites sp. nov.
Glyptocystites sp. nov.
*Numerous monticuliporoid Bryozoa.
Stomatopora proutana-pertenuis Ulrich.
Phylloporina sublaxa Ulrich.
Rhinidictya nicholsoni Ulrich.
Arthroclema sp. nov.
Pachydictya cf. foliata Ulrich.
Lingula coburgensis Billings.
Schizambon (? Siphonotreta) minnesotensis H. and C.
Crania granulosa Winchell.
Craniella ? ulrichi Hall.
Pholidops trentonensis Hall.
Plectambonites sericea (Stones River variety).
Strophomena filitexta Hall.
Rafinesquina minnesotensis Winchell.
Scenidium anthonense Sardeson.
*Orthis tricenaria Conrad.
*Dalmanella perveta Conrad.
*Dinorthis near pectinella Emmons.
*Orthis (? Dinorthis) deflecta Conrad.
Orthis (? Dinorthis) sp. nov.
Hebertella bellarugosa Conrad.
Triplecia sp. nov. (striated).
Zygospira (Hallina) nicolleti W. and S.
Zygospira (Hallina) sp. nov.
Clionychia lamellosa Hall.
Ctenodonta contracta Salter.
Eurymya plana Hall.
Tetranota obsoleta ? Ulrich.
Pterotheca attenuata Hall.
Ampyx sp. undetermined.
Harpina sp. undetermined.
Platymetopus sp. nov. near bicornis Ulrich.
Platymetopus sp. nov. near cucullus M. and W.
Pterygometopus near schmidti Clarke.
Numerous undetermined small Ostracoda of the families Cypridæ and Beyrichiidæ.

The fauna of the lower division of the Simpson formation is decidedly similar to that of the Chazy of New York and Canada and of the Pogonip formation of Nevada. Considering these east-and-west connections, it is surprising to note that the lower Simpson fauna, so far as known, contains none of the prolific fauna of the lower division (Murfreesboro limestone) of the Stones River group in middle Tennessee, which is believed to be of equivalent age. As a whole, the fauna of the upper part of the Simpson is closely related to the upper division of the Stones River group in Tennessee and Kentucky and the equivalent beds in the upper part of the Mississippi Valley.

Viola limestone.—There is a gradual transition from the top of the Simpson formation up into the basal part of the Viola formation. The top layers of the Simpson are usually argillaceous, are thinner, darker, and more evenly stratified than those at the base of the Viola, and in places contain partings and beds of clay. The rocks at the contact on each side, however, vary somewhat in different parts of the field.

The Viola formation is a continuous but slightly variable deposit of limestone 500 to 700 feet thick, which usually appears massive on very fresh exposures. Upon weathering, however, the bedding is pronounced, showing layers

SILURIAN ROCKS.

Sylvan shale.—The Sylvan shale and the succeeding Hunton limestone are comparatively thin formations, and because of their narrow outcrop they are necessarily mapped together. While these formations present strong contrasts, lithologically they belong to the same system.

The nearly pure lime deposits laid down at the close of Viola time were succeeded by dark-blue to black and green clay in apparently conformable succession. The deposition of the greenish Sylvan shale continued without interruption until it reached a thickness of from 60 to 300 feet, when it was succeeded abruptly by the Hunton limestone.

The Sylvan shale increases gradually in thickness westward. At the east end of the uplift its thickness is estimated to be 60 feet, while west of Washita River it is approximately 300 feet. Being a soft clay shale and bounded above and below by hard, ridge-making limestone, it invariably makes smooth swales or valleys, which are protected by forests. As a result fresh exposures of the rocks, especially at the contact with adjoining formations, are rare.

Only one exposure of the shale at its base was noted; this is about 2 miles northwest of Dougherty. At this place from the base upward through several feet the rock is a compact, dark-blue to black calcareous and bituminous shale, containing an abundance of graptolites and shells. Elsewhere in the shale fossils are exceedingly rare. This basal bituminous shale is harder than the succeeding greenish shale and is distinctly stratified. The greenish shale higher in the formation is homogeneous and massive and shows usually but slight indication of lamination, particularly on weathering.

A preliminary study of the fossils occurring in the dark basal shale shows the following forms:

Fossils of the lower part of the Sylvan shale.

Diplograptus sp. undetermined.
Climacograptus sp. near typicalis.
Leptograptus sp. undetermined.
Lingula; short, obtuse form.
Lingulops? sp. nov. (platform obsolete).
Leptobolus sp. near insignis.
Leptobolus? sp. nov. (has six strong radiating plications).
Conularia sp. nov., with surface sculpture very similar to that of the Trenton C. papillata Hall.
Conodonts of forms resembling those referred by Hinde to Prioniodus and Polygnathus.

The fauna of the Sylvan shale as far as known is generally remarkably similar to that of the Utica. The specific differences, however, are such as to distinguish them; yet a study of the fossils convinces one that the fauna of the Sylvan is a direct development from the much older fauna of the Utica shale and not of the intervening faunas of the Cincinnati group. From this evidence it would seem that the position of the Sylvan shale in the time scale is problematical. The highest known fauna of the Ordovician, that of the Richmond group, occurs at the top of the Viola limestone, beneath the Sylvan shale, and the Clinton occurs immediately above the Sylvan, in the base of the Hunton limestone. According to the present classification, therefore, the Sylvan shale should be correlated with the Medina, and the line separating the Ordovician and Silurian in the Arbuckle Mountains should be placed between the Viola limestone and the Sylvan shale.

SILURO-DEVONIAN ROCKS.

Hunton limestone.—The green clay shales of the Sylvan are succeeded abruptly by hard, white to light-blue limestone of the Hunton formation. Usually the contact rock at the base of the Hunton is a massive bed of oolitic limestone. Locally hard bluish limestone beds are found at the base, with rarely a thin layer of brecciated limestone or limestone conglomerate in contact with Sylvan shale. At the eastern end of the Arbuckle uplift the thickness of the Hunton limestone is estimated to be about 160 feet. It increases gradually westward on the northern side of the uplift, until it reaches nearly 200 feet in the vicinity of Franks, where it is concealed by overlap of Coal Measures conglomerates. On the southern side of the uplift, east of Washita River, the formation thins out and is absent for a distance of about 10 miles. Where it is thinnest the beds are more or less siliceous. Farther west, beyond Washita River, the formation increases until it is nearly 300 feet thick on the southern side of the Arbuckle Mountains where it passes beneath the "Red Beds" conglomerate, northwest of Woodford. On the northern side of the Arbuckle Mountains south of Washita River it is about 170 feet thick.

The Hunton formation is composed of hard, thick crystalline limestones, thin earthy limestone, and marls. It may be separated into three fairly distinct members according to lithologic characteristics, and to a less extent according to color. Except where the formation is very thin, as on the southern side of the uplift east of Washita River, the three members can always be distinguished. An average section of the formation on the south side of the Arbuckle Mountains west of Washita River is approximately as follows:

Section of Hunton limestone.

	Feet.
UPPER MEMBER.	
Semicrystalline limestones, in places cherty, interstratified with occasional thin marly layers	30
MIDDLE MEMBER.	
Marly limestones and calcareous clays, with some hard limestone layers, more abundant in the lower part	170–190

LOWER MEMBER.

	Feet.
Thick-bedded crystalline limestone succeeded by hard thin limestone with occasional marly layers. At the base of this limestone is an oolite, 4 to 5 feet thick, which locally is silicified	35–40

The upper member contains locally, at the top, beds of crystalline and very cherty and flinty limestone. While the thickness of the formation becomes greater westward, that of the individual members does not increase in the same proportion, as the greatest variation in thickness of the formation is due to the middle member. West of Washita River the upper member has a thickness of 10 feet on the northern side of the Arbuckle Mountains and 30 feet on the southern side. East of the same river it increases northward from a thin bed on the southern side to 35 feet on the northern side of the uplift near Franks.

The lithologic differences by which the members are distinguished are accompanied by faunal changes which afford a basis for age distinctions. The more massive crystalline beds in the lower part of the basal member, ranging in thickness from a thin bed to 25 feet or more, contain the following forms, which are distinctly Clinton. The four Bryozoa and the *Triplecia ortoni* are characteristic of the Clinton limestone of Ohio, and their horizon occurs in the St. Clair limestone of northern Arkansas.

Fossils of the lower member of the Hunton formation.

Favosites favosus Goldfuss.
Rhinopora verrucosa Hall.
Phænopora magna Hall and Whitfield.
Pachydictya bifurcata (Van Cleve) Hall.
Hemitrypa ulrichi Foerste.
Orthis flabellites Hall, var.
Triplecia ortoni Meek.
Atrypa marginalis Dalman.

The hard thin limestone beds in the upper part of the basal member contain the fossils listed below, which indicate Niagara age.

Fossils of the upper layers of the lower member of the Hunton formation.

Thecia swinderiana Roemer.
Orthothetes subplanus Hall.
Atrypa reticularis var.
Platyceras niagarense Hall.
Strophostylus cyclostomus? Hall.
Orthoceras sp. undetermined; very slender.
Calymene niagarensis Hall.

The middle member of the Hunton limestone as a whole is abundantly fossiliferous, the *Camarocrinus* horizon especially, near the middle of the member, being remarkably persistent. The fossils listed below are some of the easily recognizable forms:

Fossils of the middle member of the Hunton formation.

Streptelasma waynense Safford.
Favosites conicus Hall.
Camarocrinus ulrichi Schuchet.
Camarocrinus stellatus Hall.
Orthostrophia strophomenoides Hall.
Dalmanella subcarinata Hall.
Rhipidomella oblata Hall.
Bilobites varicus Hall.
Strophonella punctulifera Hall.
Strophodonta varistriata.
Uncinulus nucleolatus Hall.
Delthyris perlamellosus Hall.
Spirifer cyclopterus Hall.
Anastrophia verneuili Hall.
Gypidula galeata Dalman.
Rensselaeria aequiradiata Conrad.
Rhynchospira formosa Hall.
Meristella arcuata Hall.
Megambonia lata Hall.
Orthoceras rude Hall.
Dalmanites pleuroptyx Green.
Phacops logani Hall.
Phacops hudsonicus Hall.
Proetus protuberans Hall.

With a list of species like the above there can be no question as to the Helderbergian age of this member of the Hunton formation.

The uppermost member of the Hunton formation is probably lower Oriskany in age and equivalent to the Camden chert of Tennessee. The fossils secured from this member are not now at hand, so it must suffice for the present to say that they consist chiefly of Gasteropoda and large crinoid columns. According to the classification of the Paleozoic rocks at present in vogue, this member should be called Devonian, but it is so intimately united, both faunally and structurally, with the underlying Helderberg member, that, for this region at least, it would be doing a violence to the natural classification of the rocks to draw a line of systemic importance between them. According to a classification taking into account both the life history and structure of the strata, this divisional line should be drawn either between the flinty beds at the top of the Hunton limestone and the base of the black shale and chert of the overlying Woodford formation, or between the Niagara and Helderberg members. In the latter case the lower member only would be Silurian, and the two upper members Devonian.

DEVONIAN ROCKS.

Woodford chert.—Excepting the flinty Oriskany limestone occurring locally at the top of the Hunton limestone and possibly the Helderberg member of the latter, Devonian rocks in the Arbuckle region are limited to a single formation of chert and black shale, known as the Woodford chert. While this chert is apparently conformable with the limestone below in any single locality, it appears that this is not true in a broad sense. The Oriskany beds at the top of the Hunton limestone, consisting of several feet of cherty limestones, are present in one place but do not occur in another. In the northeastern part of the uplift, notably near Franks, cherty limestones are present at the top of the Hunton. Near the western end of the uplift, on the southern side of the Washita Valley, this upper member of hard limestone is absent and the thickness of the entire formation is reduced to a little over 100 feet. In all places there is an abrupt change in sedimentation from the top of the Hunton limestone to the chert or shale of the Woodford formation.

The Woodford chert has an estimated average thickness of 650 feet. It varies somewhat in lithologic character. In places massive chert rests upon the limestone; in other places black shale occurs at the base of the formation. As a rule, however, the formation becomes less cherty from the base upward. It is usually even bedded, occurring in layers from a few inches thick to thin laminæ. In places, especially in the northeast side of the uplift, the formation is composed almost entirely of thin, fissile, siliceous and distinctly bituminous black shale. In this part of the region, a few miles west of Hunton, lentils of almost pure flints were noted interstratified with the black shale near the base. In the western part of the region bluish shales were seen interstratified with the black shale in the upper part of the formation. At various positions in the section, especially in the more cherty beds, are small, rounded, marble-like concretions of a calcareous nature. In places there are large segregations of a similar character, concentrically banded, which occur intersecting several layers of cherty shale.

The Woodford chert is present throughout the Arbuckle region wherever its horizon reaches the surface. In the southern part of the uplift massive beds of Sycamore limestone occur above it, and the equally prominent Hunton limestone beneath it, and since these rocks are steeply tilted the Woodford chert crops in gullied valleys and rough hilly land between the prominent ridges of limestone. Elsewhere it occurs as gullied slopes and rough woodland bordering Hunton limestone ridges.

Fossils are very rare in the Woodford chert, and those found are not well preserved. In the lower part of the formation in the western part of the region a small *Lingula* of the type *L. spatulata* Hall and a few conodonts have been observed. In the shales of the upper part the only recognizable fossils seen are two concentrically plicated species of *Productella*, one of which seems referable to *P. concentrica* Hall. Fragments of fossil wood were found on the surface in many places, but with one exception it could not be determined whether they belonged with the chert or with the Cretaceous beds which are considered to have extended over the region. In one instance, however, in the southern side of the uplift northwest of Norton, a tree trunk approximately 15 inches in diameter was found embedded in the chert in the lower part of the formation. The chert here is steeply upturned and the fossil tree rests parallel to the bedding. Thin sections of the wood have been studied microscopically by Mr. David White, of the United States Geological Survey, and determined to belong to a species of *Dadoxylon*, a form common to the Devonian.

This formation is believed to be of the age of the Chattanooga formation of Tennessee, the Ohio shale of Ohio, and the Portage and Chemung of New York. At the top it doubtless includes strata corresponding in age with the Noel shale of northern Arkansas and the basal shale of the Tullahoma formation of Tennessee, which are believed to be of Kinderhook age, or, according to the present classification, earliest Carboniferous.

At present it is not possible to determine the exact parting between the Devonian and Carboniferous, since there is no clear stratigraphic distinction in the shales, and fossils are rare.

CARBONIFEROUS ROCKS.

MISSISSIPPIAN SEDIMENTS.

Sedimentation continued through lower Carboniferous time without apparent cessation. With the exception of a limestone lentil occurring near the base on the southern side of the Arbuckle uplift, the whole section of Mississippian rocks, approximately 1,600 feet thick, consists of black and blue clay shales. The black shales contain argillo-calcareous and limestone concretions and segregations, and the blue shale carries small ironstone concretions, occasional local sandstone strata, and small lime septaria.

Sycamore limestone.—The limestone outcrops very near the base of the Carboniferous throughout the southern side of the uplift. It occurs also on the northern side of the main Arbuckle Mountain and extends eastward into the central part of the uplift almost to the granite. It is mapped and described in the Tishomingo folio under the name Sycamore limestone. This rock is a light-bluish to yellow and probably argillaceous massive limestone. Upon weathering it separates into thin beds, a foot and less in thickness, and changes to shades of yellow. Near the extreme western end of the Arbuckle Mountains it has a thickness of nearly 200 feet. Near Washita River in the central part of the Arbuckle uplift the limestone has a thickness of about 50 feet, but it thins out eastward near the granite in the northeast corner of T. 2 S., R. 3 E. Elsewhere in the uplift, toward the northeast, it is absent or represented by local thin siliceous limestone strata at the top of the Devonian chert. No fossils have been found in this limestone.

Caney shale.—The remaining Mississippian strata above the limestone are mapped as the Caney shale in the Atoka and Tishomingo folios. This formation consists in the basal part of black bituminous clay shale containing limestone and argillo-calcareous segregations. This black shale grades upward into bluish shale containing small clay ironstone concretions and occasional lime septaria. The rocks. These older formations were sharply folded and eroded prior to the deposition of the "Red Beds."

Near the base the "Red Beds" deposits consist of local limestone conglomerate composed of well-worn limestone pebbles in a calcareous and usually red clay matrix, red and bluish clays, grit, and sand. The limestone conglomerate occurs only above and in the vicinity of the Silurian and Ordovician limestones and Carboniferous limestone conglomerates from which its limestone pebbles were derived. Westward, away from the source of the deposits, the limestone conglomerate changes gradually to a bed of massive, tough argillaceous limestone. In the vicinity of the outcrop of the Devonian chert a large part of the basal deposits of the "Red Beds" consists of fragmental chert, sand, and clay. Above the Carboniferous strata of sandstone and shale the basal deposits are composed of gritty sandstone, sand, and bluish and red clay.

These "Red Beds" deposits are exposed on the plain from the Arbuckle Mountains westward to and around the Wichita Mountains, and are described more fully in the discussion of the geology of the Wichita Mountains (pp. 72–76).

CRETACEOUS ROCKS.

The relations of the Cretaceous sediments to the older rocks of the Arbuckle region have been explained under the heading "Physiography of the Arbuckle Mountains" (pp. 13–16). The Cretaceous rocks rest upon a nearly flat floor, slightly inclined southward from the southern edge of the Arbuckle region. The basal formation of the Cretaceous is known as the Trinity. It has a thickness approximating 240 feet and consists of sand with local conglomerate at the bottom. The Trinity sand is followed by a nearly pure limestone formation, 20 to 30 feet in thickness, known as the Goodland limestone. Succeeding the purer limestone there are blue clay marls, white limestones and marls, ferruginous clays with thin shell limestones, and finally a thin fossiliferous limestone at the top of the lower Cretaceous. These formations, known as the Kiamitia clay, Caddo limestone, Bokchito formation, and Bennington limestone, respectively, aggregate nearly 840 feet in thickness. Each is conformable with its contact formations, and all dip toward the south-southeast at a grade approximating 40 feet to the mile. At the close of the lower Cretaceous the sediments were lifted above the sea, but not folded. Slight erosion was followed by depression and the deposition of the extensive ferruginous sand and clay which constitute the basal formation of the upper Cretaceous. This basal formation of the upper Cretaceous is known as the Silo sandstone, and is in part at least of Dakota age. These Cretaceous formations have been carefully mapped and are described in detail in the Atoka and Tishomingo folios. South of Red River above the Silo sandstone is a thick formation composed of blue clay shales. These are succeeded by white, chalky limestones, and these in turn by blue marls, which extend to the top of the upper Cretaceous in southeastern Choctaw Nation and northeastern Texas, beyond the limit of the area shown on the accompanying map (Pl. I).

STRUCTURE OF THE ARBUCKLE MOUNTAINS.

In discussing the physiography of the region it was necessary to make brief mention of the orogenic movements involved in the Arbuckle uplift. The history of the geologic structure will be described more fully in the following pages.

In discussing the stratigraphy it has been shown that the formations remained in an approximately flat position from the earliest Cambrian to the end of Mississippian time. That there were oscillations of the ocean bed, and probably elevations of the sediments into lowlands at times, is shown by the varying nature of the rocks. A study of the fossils by Mr. Ulrich has shown without much doubt that comparatively short intervals of nondeposition and probably of slight erosion have occurred. The first change in sedimentation, and probably slight erosion, occurred between lower and middle Cambrian time, when argillaceous limestones, intraformational conglomerates, and clays were succeeded by massive limestone. Another change occurred at the end of the Arbuckle limestone deposition, as there is an abrupt transition from Arbuckle limestone to the basal sandstone of the Simpson formation, which is of Chazy age. Other breaks occurred at the close of the Simpson formation, where there is a change from siliceous to purer limestone sediments; at the top of the Viola formation, where there is an abrupt change from limestones to clays; and at the close of the Sylvan, where there is an equally abrupt return to limestone of the Hunton formation, which was introduced locally by deposits of conglomerate. The rock bedding, however, remained practically parallel, and the sediments, with the exceptions noted, are finely divided and evenly distributed, showing that the oscillations of the sea bottom were of broad extent and that if erosion occurred it was in very low and flat land. It is neither impossible nor improbable that a break in the fauna accompanied by a change in sedimentation may be due to marine conditions, a prominent part being performed by ocean currents. A belt of shallow sea bottom swept by an ocean current, it is considered, would receive neither the fauna nor the sediments being deposited in a district of more quiet waters.

Near the beginning of the Pennsylvanian or near the close of the Mississippian, the rocks of the Arbuckle region were folded and the western part was elevated into land, probably into mountains. The formations involved in this uplift are 8,000 to 10,000 feet in thickness, and are composed chiefly of massive limestone. Faulting on a large scale also occurred, involving the whole Paleozoic section below the top of the Mississippian, besides the pre-Cambrian granite and porphyry. After the elevation into land there was extensive erosion, which exposed the rock section down to the Cambrian in the western part of the Arbuckle Mountains. Either by erosion or by erosion and subsidence combined the western part at least of the uplift was submerged and large deposits of Carboniferous conglomerate were spread across the edges of the older faulted and folded strata. At a still later time, before the close of the Carboniferous, the sediments were again folded and elevated into land. This folding affected the recently formed conglomerates as well as all the rock previously deposited. Faulting occurred also after the deposition of the conglomerate. Near the close of Carboniferous time another period of subsidence occurred and the "Red Beds" sea encroached upon the region from the west. The extent of this encroachment eastward is not now determinable beyond the vicinity of the present occurrence of the deposits. These deposits have not suffered deformation to any appreciable extent. At a later period, between Permian and earliest Cretaceous times, the whole region was elevated into land. Following this regional elevation there was depression and a reduction of the surface to a relatively flat plain. Then followed a submergence and the deposition of the Cretaceous sediments. After Cretaceous time the region was broadly uplifted into land, without deformation, and has so remained to the present time.

The deformation of the rocks now exposed in the Arbuckle region commenced near the beginning of upper Carboniferous time and ended before its close.

CHARACTER OF FOLDING AND FAULTING.

The Arbuckle uplift includes a number of low, wide anticlines and corrugated faulted synclines, which together make a broad geanticline, the borders of which are flexed steeply downward. As explained in discussing the stratigraphy, erosion has removed the rocks down to the heart of the uplift, exposing all the sedimentary rocks as well as the pre-Cambrian granite and porphyry. In the faulted synclinal folds in the central part of the uplift, which have depressed and preserved later softer and thinner formations, there are indications of more complicated folding than occurs in the massive Cambro-Ordovician limestones.

The geologic sections accompanying the map (Pl. I) show the broad as well as the detailed structure of the Arbuckle uplift. The central part of the uplift east of Washita River is composed of several broad, shallow folds. In the axial parts of the anticlines great thicknesses of massive Cambro-Ordovician limestones are exposed and are generally but slightly flexed. The thinner and softer Silurian, Devonian, and Carboniferous rocks in the intervening synclines have been crumpled into many small folds. These synclines are broken, in general longitudinally, by many faults. Since the faulting erosion has so removed the strata that only parts of these numerous small folds in the broader synclines are now preserved. The essential features of the folding and faulting will be described, beginning with the north side.

Hunton anticline.—On the northern side of the Arbuckle uplift, beginning in the vicinity of Hunton and extending northwestward, the rocks have been bent into a broad and low upward fold, which is sharply flexed and faulted on the northern side and faulted throughout the southern side. In its western part it is 15 miles in breadth and extends over almost half the width of the Arbuckle Mountain district. Eastward the fold grows gradually narrower for 20 miles, where it is contracted more abruptly by the axial pitch of the rocks and by the oblique faulting. The faulting upon the northern side of this fold is local, the fractures bearing generally east and west at various angles to the axial trend of the main anticline, but in most cases across or oblique to the strike of the formations. The longest of these faults, however, follows the strike of the beds in the northwest side of the fold. The displacement of the beds due to this fault decreases northwestward. Near the southeastern end the whole of the Simpson formation is displaced, bringing the succeeding Viola limestone against the Arbuckle. Some of these local faults extend from the thick Ordovician limestones, across Silurian and Devonian strata, into the Carboniferous shales, and the rocks upon the north are generally depressed with respect to those upon the south in the direction of the dip of the strata. In T. 2 N., R. 6 E., near the extreme northern limit of the uplift, there is a triangular basin of Carboniferous limestone conglomerate resting unconformably across older Paleozoic rocks. The beds are steeply upturned upon the northwestern and southwestern sides, and faulting has occurred at the contact of the conglomerate with older rocks, so that the rocks are depressed by faulting as well as by folding. The faulting upon the southern side is more extensive, with downthrow toward the south. The rocks on the southern side of the Hunton anticline are inclined at low angles except locally near the faults, where the dips are usually increased. In the axial part, and near the western end of the anticline, where it is overlapped and concealed by later Carboniferous strata, there are local shallow basins, and at the extreme western end a local basin containing rocks of the Simpson formation has been faulted down as a triangular block in the Arbuckle limestone. For the most part the faults bordering this depressed block bear east and west, with displacements toward the south. A single fault bearing northeast intersects the faults in the axial trend and displaces the rocks downward toward the west.

Wapanucka syncline.—A flat and eastward-pitching syncline occurs immediately south of the Hunton anticline. In the broad, flat valley of Wapanucka Creek, from which it has received its name, its axial part is occupied by Mississippian shale. This fold becomes broader and flatter eastward, until it is lost in the Coal

Measures northeast of the Arbuckle uplift. Toward the west it contracts by faulting upon each side until it practically ceases as a fold in the northern part of T. 2 S., R. 7 E. Parts of the syncline may be said to occur along the fault which extends through the uplift on the south side of the Hunton anticline. The south limb of the Wapanucka syncline is intersected by many faults, which have strikes varying from transverse to directions parallel with the trend of the folding. A striking characteristic of the faulting is that the older and harder rocks, including the granite, are displaced to a greater extent than the soft Carboniferous shales. On the southern side of the Wapanucka syncline the faults are more numerous than on the northern side, and with the exception of a local transverse fault west of Wapanucka the depression of the strata due to faulting is in all cases toward the axial part of the syncline.

Excluding the transverse fault referred to, the faults may be considered in two classes, viz, those which bear nearly east and west, and those which trend in northwest-southeast directions, more nearly with the strike of the rocks. These two classes of faults, however, coalesce, and by their junction augment the displacement of the strata. Many of the larger faults have vertical displacements of several thousand feet, and, where two such approach, the throw is doubly great. Two nearly parallel faults approach each other south of Wapanucka, and their combined throw brings Devonian shales almost in contact with the granite, concealing 8,000 feet of Cambrian, Ordovician, and Silurian strata.

The faulting in the northern side of the syncline bears nearly N. 70° E., intersecting the older rocks almost at right angles to their strike, and the rocks in all cases are depressed southward toward the axis of the syncline. The displacement due to faulting in the northern limb of the Wapanucka syncline is less than that on the southern side, and as a consequence the resultant throw west of their junction is downward toward the north, along the axial trend of the fold.

Belton anticline.—The elongated granite area which extends from the southeast end of the Arbuckle uplift northwestward beyond Belton occupies the axial part of a poorly defined anticlinal fold. Both sides of this fold have been faulted in such manner that the rocks represented in it occupy only the axial part. The stratified rocks now in this fold above the granite consist of massive Cambrian and Ordovician limestones which are folded only to a moderate degree and which strike toward the fault at various angles. Near the faults on either side of the fold the beds are usually more steeply inclined toward the fault or locally folded. In places, however, only a slight increase in dip is all the disturbance to be noted on account of the fault. The contacts between the granite and limestones, with the exception possibly of that at the west end, are marked by faults, and on both northern and southern sides the stratified rocks are depressed with respect to the igneous mass, and the dip near the fault is usually toward the downthrow. The faults marking the limits between the granite and the limestone at the east end of the anticline extend westward and bound the long block of Arbuckle limestone which constitutes the axial part of the fold. The rocks upon each side of this faulted anticlinal block have been depressed with respect to the rocks within. The Belton anticline is concealed by Cretaceous deposits toward the southeast and by Carboniferous conglomerates toward the northwest.

Mill Creek syncline.—The district of most intricate folding and faulting in the Arbuckle region is a narrow strip of country immediately south of the Belton anticline in the central part of the Arbuckle uplift. The belt varies from one-half mile to 3½ miles in width and is as a whole synclinal. The town of Mill Creek, for which the syncline is named, is located near its center. The syncline consists of parts of many subordinate folds, bearing generally northwest and southeast, in the trend of the Arbuckle uplift, and is bounded upon each side by well-defined faults. These bounding faults, as well as most of those in the interior of the syncline, trend generally parallel with the main folding of the uplift. In no case, however, do the faults follow straight lines for any considerable distance. While the fault lines take the general direction of the major folding, the beds usually strike against them on one side or the other, and in places on both sides, at angles between 30° and 90°.

The rocks occurring at the surface and involved in the folding and faulting include the entire section from the Cambrian to the Coal Measures and have a thickness approximating 10,000 feet. The rocks exposed in the smaller folds are for the most part the thinner and softer formations of the Silurian, Devonian, and Carboniferous. It is probable that these folds in the higher rocks are minor crumplings which were developed in the axial part of the syncline, above the broader trough of the thick and hard deep-seated limestone, before the faulting occurred. These massive limestones exposed in the eastern part of the fold are for the most part gently inclined, approaching the faults upon each side at wide angles. The faulting, especially in each side of the fold, is very extensive, and in places brings the Carboniferous rocks in contact with the Ordovician and the upper Ordovician strata against the granite, showing displacements of several thousand feet.

For the most part the folding and faulting occurred before the deposition of the Carboniferous conglomerate which extends across the western end of the fold. Certain faults in the vicinity of Mill Creek and near Buckhorn, however, occurred since the deposition of the conglomerate, which is involved in the disturbances.

Parts of folds in Cambrian and Ordovician limestone occur faulted against the granite at the extreme southeastern end of the uplift. So large an area is overlapped and concealed by Cretaceous strata that the relations of these parts of folds to other structures can not be determined. Parts of two flat irregular synclines are represented and the faulting appears to follow their axial trends. Near the east end of the limestone exposures the 5,000 to 6,000 feet of Arbuckle limestone is cut at right angles to the bedding and brought against the granite.

Tishomingo anticline.—South of the Mill Creek syncline and forming the southern part of the Arbuckle Mountain region is a broad, flat fold called the Tishomingo anticline. The large granite area lying northwest of Tishomingo occupies the axial part of this anticline. Above the granite and upon its western side the whole section from lower Cambrian to Carboniferous is exposed, pitching westward at an angle of about 10°. The northern limb of this anticline is for the most part displaced and concealed by faulting. A large part of the southern limb of the fold is also concealed by faulting from the vicinity of Wyatt eastward. Bordering the granite on the south side, this fault cuts the whole section of stratified rocks from Cambrian to Carboniferous, and displaces them in such manner that the formations rest consecutively against the granite. North of this fault, which extends along the strike of the rocks from the granite westward to Washita River, the rocks dip generally at low angles toward the west and southwest. On the southern side the rocks strike approximately with the trend of the fault and dip steeply toward the southwest. Northeast of Dougherty the Tishomingo anticline contracts and separates into two minor folds, the northernmost of which pitches rapidly downward toward the northwest and is lost beneath late Carboniferous conglomerate which overlaps older sediments. The second fold is the western extension of the central part of the anticline. The rocks in the axial part pitch northwestward at an angle of about 20 east of Dougherty, and rise again at about the same angle northwest of the same place. This fold continues northwestward, expanding slightly, until it also is concealed by late Carboniferous and recent river deposits.

Two to 5 miles northwest of Dougherty, and south of the western contracted end of the Tishomingo anticline, is a peculiar dome-like anticline less than a mile in width, with north-south axis. The occurrence of this local fold deflects the Tishomingo anticline slightly northward. On the northwestern and southeastern sides of this dome-like anticline there are small synclines, and their sharp north ends rise in the south side of the Tishomingo anticline. The southern part of this dome-like anticline is concealed by the sand and silt deposits in the valley of Washita River.

Washita syncline.—Just south of the Tishomingo anticline, near the point where Mill Creek crosses the large fault, is a faulted southern limb of a syncline. It is also a part of the northern limb of a narrow anticline which trends toward the northwest and approaches and is cut by the fault east of the center of T. 5

S., R. 4 E. This broken anticline is probably a part of the Arbuckle anticline described below. A local narrow synclinal fold occurs on the northern side of the same fault in sec. 2, T. 3 S., R. 3 E., and its southern limb is faulted downward and concealed. These two parts of synclines are similarly related to the Tishomingo anticline and trend in the same direction, but the fault conceals their true relations. The second small syncline rises toward the west and then descends near the western side of T. 2 S., R. 3 E., becoming a part of the deep Washita syncline, which lies beneath the valley of Washita River northwest of the gorge in the Arbuckle Mountains.

The southern limb of the Washita syncline is steeply upturned. The beds exposed south of the river valley dip toward the northeast at angles varying between 40° and 70°. In the northeastern side of the fold, east of the dome-like anticline described in connection with the Tishomingo anticline, the rocks are inclined toward the southwest at angles of about 30°. Northwest of the dome-like fold the dips are steeper. It is believed that the southern extension of the dome-like anticline does not pass beyond the axis of the syncline, since the exposed rocks in the southern limb show no indication of transverse stresses.

The sand and silt deposits of Washita River conceal the axial part of the fold, which contains a thick section of Carboniferous shale. The northwestward extension and probably a large part of the Washita syncline is covered by overlap of late Carboniferous conglomerate, which conceals the westward extension of all the large folds of the Arbuckle uplift.

Arbuckle anticline.—South and west of Washita River is a broad and steep-sided anticline which is occupied by the Arbuckle Mountains proper. The fold converges practically to a point east of Washita River, and pitches steeply eastward between converging faults. Northwestward the fold expands until it reaches a width of 15 miles at the western end of the mountains, where the rocks involved in the folding are overlapped and concealed by Pennsylvanian and "Red Beds" conglomerate. Section AB on the map (Pl. I), drawn across the west end of the fold, illustrates the character of the structure.

The rocks near the northern and southern borders dip at angles of 30° to 70°, while in the axial part of the fold, especially through the broader western portion, the inclination of the thick Cambro-Ordovician rocks is usually much lower, though locally variable. In the eastern part, near the Washita River gorge, the folding has been more intense. Only the general features of the structure have been worked out and shown on the accompanying small-scale map.

In the axial part of the anticline, near the center and the western end, are two unsymmetrical dome-like structures in which pre-Cambrian igneous rocks are exposed. The rocks in the northeastern sides of these domes are more steeply inclined, besides being faulted. The more easterly of these elevations, known locally as the East Wooded Hills, is the smaller, and is bounded on the northeast by a curved fault, giving the igneous area a rudely crescent-shaped outline. The massive Cambrian limestone on the east side dips away from the igneous mass in the direction of the downward displacement.

The more westerly dome-like elevation of the strata in the Arbuckle anticline, known locally as the West Wooded Hills, is broken on the northern side by a number of faults which have approximately the same direction as the trend of the fold, and on the southwestern side by a single fault near the western end. Four faults have been located on the northeastern side. The two faults which border the granite are gently curved or fluted and the Cambrian limestone is displaced downward toward the north. The vertical throw can not be accurately estimated, but it is probably not less than 500 feet where the Reagan sandstone is concealed. The second two faults have caused greater displacement of the strata. They are near together, are nearly parallel, and converge at the western side of sec. 12, T. 1 S., R. 1 W. Between these faults a narrow wedge of the Simpson formation is thrown down between massive strata in the lower part of the Arbuckle limestone. A fault in the strike and southeast of the depressed wedge of Simpson limestone cuts the southeastern lobe of the igneous mass, throwing the Cambrian limestone down on the southwestern side of a tongue of porphyry. It is presumed that this is the southwestward extension of the more northerly of the two faults above referred to. The fault on the southwestern side of the West Wooded Hills has a more easterly bearing than those on the northeastern side. Toward the east it enters the granite and is lost to view. Toward the west it passes into the thick Cambro-Ordovician limestone and probably beneath the overlapping Carboniferous conglomerate. The bearing of this fault is oblique to the strike of the rocks, and the displacement of the strata is downward toward the south, concealing the Reagan sandstone. The beds on each side, especially those near the base of the section, strike against the fault at high angles.

Local folding and faulting have occurred near the border of the Carboniferous conglomerate east of the West Wooded Hills. A strike fault in this district separates the Viola limestone from older formations on the west. It is evident that the displacement of the rocks on the northeast side is downward with respect to those on the opposite side. Southeastward the fault passes beneath an area of Carboniferous limestone conglomerate, which was deposited on eroded edges of the Cambrian and Ordovician rocks after the folding and faulting in this district occurred. Farther toward the southeast and extending to Washita River it is believed that the same fault continues in the strike of the Simpson formation. Its exact location, however, is difficult to determine. The displacement appears to increase southeastward, since the Simpson formation becomes gradually thinner in this direction by the loss of lower beds, until only a remnant of its thickness is present where its outcrop approaches Washita River. In the river valley the fault cuts across the Washita syncline, bringing successively Silurian, Devonian, and Carboniferous rocks in contact with the Cambro-Ordovician Arbuckle formation. East of Washita River the throw decreases, and practically ceases near the southeast corner of sec. 29, T. 2 S., R. 3 E. From approximately the same place a fault already described extends through the south limb of the Tishomingo anticline. The displacement of the rocks of this fault, however, is downward toward the south.

A second fault occurs in the rocks north of the East Wooded Hills. It joins the first near the western side of sec. 24, T. 1 S., R. 1 E., and bears toward the west, with downthrow toward the south. Thus between the two faults there is an obtuse wedge of older rocks which has been elevated with respect to the formations that occur on opposite sides of the faults.

It has been explained that the Arbuckle anticline near the crossing of Washita River and beyond toward the southeast is much contracted and strongly folded and faulted on both sides. The faults on the northern side have been described. On the southern side the disturbances are more complex and are difficult to interpret. Two and possibly more faults cross Washita River nearly in the trend of the folding, and converge toward the southeast near the southern side of sec. 31, T. 2 S., R. 3 E. The resulting displacement, when they converge, is such that Carboniferous shales are thrown down on the south and brought in contact with Ordovician limestones. In sections 32 and 33 of this township the same shales are faulted against Ordovician rocks, but on the northern side. A fault transects the fold obliquely to its trend, bearing southeast from the northern side, and approaches and seems to join the above-named converging faults near the southeast corner of section 32. Here it turns eastward in the south side of the narrow pitching end of the Arbuckle anticline, dividing Carboniferous rocks lying on the north from Ordovician limestone on the south.

Near the southern side of section 34 a narrow fragment of massive Arbuckle limestone a half mile in length is apparently projected into the Mississippian shales. The limestones are steeply upturned and the shales in exposures near by are intimately crumpled and slickensided. An attempt at explanation of the forces which produced the disturbances of the rocks would not be satisfactory without further detailed work, but it appears that there have been movements of the strata along the fault planes in the trend of the folding and that the long and narrow wedge of limestone referred to above has been thrust into the Carboniferous shales.

The rocks in the southern limb of the Arbuckle anticline have been crumpled to a small extent, apparently by forces acting in the direction of the trend of the fold. Local transverse folds occur in the strongly tilted southern limb of the anticline, and two of these are faulted. One instance was noted near Woodford and the other 6 miles east. The trend of the one is toward the northeast, while that of the other is toward the northwest. In each case the faults are traceable from the Carboniferous shales on the south into the thick Ordovician limestones on the north by means of the discordant contacts and local crumpling of the strata, due to the lateral drag on either side. Between these faults, which approach each other almost at right angles, the triangular block of strata has moved southward, or upward, with respect to the rocks on the opposite sides of the faults.

NOTES ON THE OCCURRENCE OF ORE DEPOSITS OR PRECIOUS METALS IN THE ARBUCKLE MOUNTAINS.

It has been shown in the discussion of the stratigraphy of the Arbuckle Mountains that all of the igneous rocks, including the dikes, were formed in early Cambrian or pre-Cambrian time, and that they probably suffered long erosion before the oldest sedimentary rocks were deposited. The various classes of igneous rocks, including the dikes, show no indication of faulting, fissuring, or shearing along their contacts with one another. On the contrary, there is every indication that the intrusions of granite-porphyry, aplite, or diabase as now exposed occurred at great depths, and that no occasion has been given for the passage of meteoric waters which would cause replacement or mineralization of the rocks along their contacts.

It is true that the igneous rocks, as well as the stratified rocks, of the Arbuckle region have been extensively faulted, but these faults occurred long since the formation of the igneous rocks, and they have nothing to do with the relations of the different kinds of igneous rocks with one another. All the fault contacts between the igneous and stratified rocks have been carefully traced, but no indication of the mineralization of the rocks or the occurrence of ore deposits of any consequence along them have been noted. There is nothing in the topography to aid one in tracing lines of faulting in the igneous rocks, and they are so deeply weathered or concealed by soil or surficial sand that a structural feature can not be traced for any considerable distance.

Many of the dikes, chiefly those of diabase cutting the granite, have been prospected at various times for the precious metals without any show of profit, and the sum of all information obtainable gives no assurance that ore or metal deposits of any value can be found in the region.

NOTES ON THE GEOLOGY OF THE CRINER HILLS.

Fifteen miles south of the Arbuckle Mountains and 6 miles southwest of Ardmore is a small uplift, locally known as the Criner Hills, in which are exposed all the formations occurring in the Arbuckle uplift except the pre-Cambrian igneous mass, the Reagan sandstone, and the lower part of the Arbuckle limestone.

STRATIGRAPHY.

The formations occurring in the Criner Hills include a complete section from near the top of the Cambrian up to the Carboniferous, and they are found to contain in all respects the characters appearing in the same formations in the Arbuckle Mountains, described above. A detailed description of their lithology, therefore, is not considered necessary in this place. The location and areal extent of the formations may be seen on the map.

TOPOGRAPHY.

Physiographically the Criner Hills are the Arbuckle Mountains in miniature. Composed of the same formations steeply folded and exposed to erosion in early Cretaceous time, the district was reduced to a low plain and submerged. In comparatively recent geologic time the Cretaceous deposits were removed, again exposing the older rocks to the action of erosion. It will be observed that the Criner Hills lie in an angle formed by Hickory Creek and its tributaries, and are bounded on the northeast and southwest by Cretaceous sand, the base of which, if continuous, would fall practically in a plain cutting the crests of the hills. In fact, a remnant of the Cretaceous sand may yet be seen on Carboniferous rocks at the southeast end of Criner Hills. Since the removal of the Cretaceous sand erosion has gone on more actively in the soft Carboniferous rocks than in the older and harder rocks, thereby developing the hills.

The plain at the base of the Cretaceous which falls in the crests of the Criner Hills is the same as that which marks the high levels of the Arbuckle Mountains. It was produced by the base-leveling erosion which advanced northward with the sea across the region in early Cretaceous time.

Like the larger streams in the Arbuckle region, Hickory Creek and its larger tributaries in the vicinity of the Criner Hills were imposed on the older and variably hard rocks from formerly established drainage channels in the more homogeneous southeastwardly inclined Cretaceous strata. Thus, like Washita River in the Arbuckle Mountains, Hickory Creek cut into the rocks of the Criner Hills, and is still deepening its gorge across the hard Ordovician limestones as erosion of the softer strata of the surrounding region continues to lower its surface below the plain of the Criner Hills.

The minor details of Criner Hills topography depend upon the character of the rocks composing the exposed formations. As in the Arbuckle Mountains, the Arbuckle limestone, being a massive and comparatively homogeneous formation, makes irregular stony hills, while the Viola and Hunton limestones, consisting of thinner though comparatively harder beds, make oval and smooth hills and ridges. The Sylvan shale is invariably in valleys or swales, and the Simpson formation, which is in large part composed of soft rocks, is usually occupied by valleys and lower hill slopes.

STRUCTURE OF CRINER HILLS.

The relations of the Pennsylvanian beds to the older rocks are essentially the same as in the Arbuckle Mountains, so far as could be determined by a general survey. The Sycamore limestone and Caney shale of the Mississippian occur infolded with the older rocks, and it seems evident that in this area, as elsewhere in the Arbuckle Mountain region, active disturbances of the rocks did not occur until about mid-Carboniferous time. Sufficient fossils, however, were not obtained to determine the position of the lowest Pennsylvanian beds exposed in the district.

There is a pronounced unconformity at the base of the Coal Measures strata across the northwestern end, in a large portion of the northeastern side, and at the southeastern end, of the hills. The lowest exposed beds of the Coal Measures consist of gritty siliceous limestone, sandstone, and shale interbedded, and coarse limestone conglomerates. The entire southwestern side, however, and a part of the northeastern side are marked by faults. The extent of displacement on the southeastern side is not determinable. The older rocks of the hills end abruptly in a definite but low escarpment, at the base of which a number of large springs issue. As shown by the exposures, the rocks in contact at the base of the escarpment consists of Coal Measures shales, calcareous grits, and sandstones, and dip usually toward the southwest. In the area west of Hickory Creek, except that part bordering the stream, a flat, fertile plain extends to the base of the escarpment.

The rocks of the Criner Hills structurally compose parts of four folds. All these folds are intersected by faults and are bounded on one or more sides by an overlap of Carboniferous deposits.

The larger of these folds includes the northwestern half of the hills and is a northeastward-dipping monocline or the broken southern limb of a syncline. Along and near the southwestern side the lowest exposed beds of the Arbuckle limestone are nearly flat and are locally deflected downward at low angles toward the fault which bounds the hills. It is interpreted that this local southwestward deflection of the rocks is due to the drag in the downward displacement on the opposite side of the fault. There are no means by which the extent of displacement of the strata along the southwest side of this fold can be determined. It is reasonable, however, to consider that the throw is not so great as the discordance in strata now in contact at the fault would indicate, but that it is, in part at least, due to an unconformable overlap of Carboniferous upon the folded and eroded older rocks before the faulting occurred.

A fault also bounds the northeastern side of this fold. It bears S. 25° to 30° E. from the northwest corner of the hills, oblique to the strike of the rocks and to the trend of the hills. The strata on the east side of the fault have been thrown down with respect to those on the west side. The axial part of a syncline occurs east of this fault, near the north end of the hills. The lowest rocks exposed here are Devonian (Woodford) cherty shales, which occur in contact with Ordovician (Viola) limestone on the opposite side of the fault. Near the north side of sec. 22, T. 5 S., R. 1 E., the fault crosses the axis of this syncline, and toward the southeast successively lower formations approach the fault on each side. This fault joins that in the southern boundary of the hills near the crossing of Hickory Creek. The downward displacements of these faults are in opposite directions, and it is evident that in the latter fault the displacement is greater, since it continues downward toward the southwest, beyond the junction of the faults, and to the southeast end of the hills. From Hickory Creek southeastward the inclination of the older rocks of the hills is 45° to 50° NE., while the Carboniferous rocks dip 25° to 30° SW.

East of the above-described fault, which cuts the hills diagonally, the older rocks comprise a remnant of an anticlinal fold, which trends approximately N. 20° W. The upper part of the Simpson formation is exposed in places both east and west of Hickory Creek, and the succeeding Viola limestone outcrops in large bodies on each side, making the southeastern part of the Criner Hills. Still higher formations, the Sylvan shale and the Hunton limestone, occur at the northwestern and southeastern ends of this broken fold. In the northwestern end they are terminated by faulting and overlap of the Carboniferous conglomerate, and at the opposite end apparently only by overlap. Faulting has occurred in the axial part of this fold also. At the crossing of Hickory Creek, in the SW. ¼ sec. 35, T. 6 S., R. 2 E., the Simpson formation is exposed only in the southern limb of the fold. It appears that the fault follows approximately the strike of the fold, and that the eastern limb has been thrown down with respect to the other. The dip of the rocks in the Simpson formation here is 80° SW., while on the opposite side the Viola limestone is nearly as steeply inclined in the opposite direction. In the eastern half of sec. 36, T. 5 S., R. 2 E., there is a small area of Silurian, Devonian, and Mississippian rocks, surrounded unconformably by Coal Measures strata. It appears to be a part of the northern limb of the anticline above described. The rocks dip toward the northeast, and are nearly in strike with the same formations at the southeastern end of the Criner Hills.

The Carboniferous rocks on the northeast side of this anticline have suffered folding, and near the contact with the older rocks are generally steeply inclined and dip toward the northeast. East of Hickory Creek dips of Carboniferous rocks at and near the contact vary from 25° to 40°, while the older rocks dip at greater angles and in places in different or opposite directions, indicating a great unconformity. Immediately east of the road at its crossing of Hickory Creek, near the west side of sec. 35, T. 5 S., R. 2 E., the contact is evidently upon a fault. At this place the Simpson formation dips toward the southwest, while the dip of the Carboniferous is 40° in the opposite direction. Farther southeast, and in the opposite side of the axis of the fold, the Viola, Sylvan, and Hunton formations dip northeast, in the same direction as, but at higher angles than, do the overlying Carboniferous strata. West of Hickory Creek, at the base of the Coal Measures deposits, is a strong unconformity which is probably in part due to faulting. The beds near the base are variable in character along this contact. In some places they appear to be chiefly shale, while in others, especially in sections 22 and 27, are coarse limestone conglomerates consisting of pebbles of the same nature as the limestones of the Criner Hills.

ARDMORE BASIN.

The region between the Criner Hills and Arbuckle Mountains may be characterized as the Ardmore trough or basin. The rocks consist of shale, limestone, limestone conglomerate, and sandstone, of Coal Measures age, and have been strongly folded. The trend of the folds is northwest and southeast, generally parallel with the Arbuckle and Criner Hills axes.

The details of the folding have not been worked out, but sufficient observations have been made to determine that the rocks have been crumpled into many folds, which together constitute a deep corrugated syncline or trough.

Like the Arbuckle Mountain and Criner Hills uplifts, the Ardmore trough is overlapped and concealed toward the northwest by Pennsylvanian or "Red Beds" deposits, and on the southeast by early Cretaceous sand. Toward the south the Carboniferous rocks are also concealed by Cretaceous deposits separating them from rocks of the same age in the north Texas coal field.

GEOLOGY OF THE WICHITA MOUNTAINS.

PREFATORY REMARKS.

PREVIOUS WORK.

The Wichita Mountain region was first visited by scientific observers in 1852, when Dr. George G. Shumard, who was physician to the expedition, commanded by Capt. R. B. Marcy, that explored the North Fork of Red River,[a] noted the occurrence of the igneous rocks of the mountains and the stratified sediments of the surrounding plains. The expedition touched many points along the southern side and crossed the northwestern and southeastern ends of the range. Captain Marcy mapped a part of the range, his map indicating that the range had a northeast-southwest direction, when in fact it trends southeast and northwest. The mountains and streams with one exception, still retain the names then applied. Tepe Creek was designated Spring Creek, and Tepe Mountain is evidently the eminence named Mount Webster by Captain McClellan. The names now locally used for this stream and mountain are too well established to admit change. Doctor Shumard noted that the sandstones and red clay surrounding the mountains were horizontal, and that the sandstone beds, where they approached the mountains, contained fragmental igneous materials. He also observed that the granite and porphyry were widespread in the mountains and that they contained "veins" of greenstone and quartz.

In 1899 Dr. T. B. Comstock and Mr. W. F. Cummins made a reconnaissance of a part of the Wichita Mountains.[b] Doctor Comstock had recently surveyed the "Central Mineral Region" of Texas, in which the older igneous and Paleozoic rocks occur, and his interpretations of structure and geologic relations made there were extended to the Wichita region. He assumed that the geology of the central Texas region—200 miles distant from the Wichita Range and separated from it by little distorted Carboniferous and Permian strata—was a key to its geologic interpretation. In the igneous masses of the Wichita Mountains post-Cretaceous structures were apparently recognized corresponding with those which were claimed to occur in the Texas region, where undisturbed Permian strata surrounds the mountains and no Cretaceous rocks are known. Doctor Comstock classed the granite-porphyries of the Carlton Mountains, the gabbro, and the diabase as lavas representing stages of eruption, and stated that there were flows and remnants of volcanic craters. He correctly noted the occurrence of older stratified rocks which were involved in the Wichita uplift, but failed to see that the diabase dikes which penetrate the gabbro and granite-porphyry as well as the granite are older than the oldest stratified rocks, which are of middle Cambrian age. Doctor Comstock named many of the mountains, locating them by numbers on his sketch map. Of these only Carlton, Cummins, Quana, and Navajoe can be definitely located.

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[a] Senate Ex. Doc. No. 54, 32d Cong., 2d sess., Washington, 1853. Appendix D.

[b] First Ann. Rept. Texas Geol. Survey, 1889, pp. 319-328.

In 1891 Mr. R. T. Hill made some general observations on the nature of the Wichita Mountains,[a] attempting to connect them structurally with the Ouachita Mountains of eastern Indian Territory. He notes the peculiar topographic features of the mountains and concludes "that their age is not determined," but that they are post-Silurian and have developed in part since the deposition of the "Red Beds."

In the fall of 1896 Mr. T. Wayland Vaughan, in making a reconnaissance of parts of Kansas and Oklahoma, investigated the older Paleozoic strata on the northern side of the range and made a collection of specimens representing the principal types of igneous rocks of the Wichita Range. These collections were studied and reported upon by Dr. A. C. Spencer.[b] Fossils were collected from certain limestones northeast of Tymate Mountain, which proved to be of Ordovician age. No effort was made by Mr. Vaughan to segregate or map the classes of igneous rocks, but his collections enlarged greatly the species of igneous rocks before known to occur in the region. Doctor Spencer recognized gabbro, granite, granite-porphyry, anorthosite, and troctolite. With the aid of a local surveyor Mr. Vaughan was able to locate, by reference to land surveys, practically all the mountains of the region which had been named, but none were mapped.

In the spring of 1899 Dr. H. F. Bain devoted a month's time to a reconnaissance of the Wichita Mountains, giving attention chiefly to a study of the mineral resources. His report[c] on the general geology is more complete than previous publications of the region. Doctor Bain differentiated and described the main classes of igneous rock, including the quartz veins, which in one instance he found were cut by greenstone (diabase) dikes. He considered that the granite was erupted through the porphyry and affected the Cambrian and Ordovician strata. This conclusion seems to have originated from a misinterpretation of structural conditions in Blue Creek Canyon. In this canyon the limestone is faulted against the granite-porphyry instead of being cut by a dike of similar rock. Cambrian rocks are recognized besides the sequence of succeeding Ordovician limestones of great thickness. The classification is substantiated by fossil determinations. Certain conglomerates composed of granite, porphyry, and limestone interbedded with shales and succeeded by shale and sandy limestone near the eastern end of the Wichita Mountains are correctly classed in age as "later than the Trenton," but instead of being older than the "Red Beds" (Permian) deposits they are evidently contemporaneous with them and form their near-shore phase. Likewise the conglomerates of limestone and various igneous rocks in the large valleys and along the borders of the Wichita and Quana groups of mountains are Permian, if the "Red Beds" are to be so classed. Beneath a zone of weathering these deposits are partially consolidated and in places associated with red clays and grits, as explained in the discussion of Permian rocks in the pages following. Along the south side of Quana Mountain, in the valleys of the larger streams, are recent surficial deposits of gravel and sand, worked over in part from the "Red Beds" conglomerate, which may be mistaken for the conglomerates in a general reconnaissance.

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[a] Notes on a reconnaissance of the Ouachita mountain system in Indian Territory: Am. Jour. Sci., [illegible] 1891, pp. 122–123.

[b] Vaughan, T. Wayland, Geologic notes on the Wichita Mountains, Oklahoma, and the Arbuckle Hi[illegible] Territory, with report on the igneous rocks by Dr. A. C. Spencer: Am. Geol., vol. 24, 1899, pp. 44–55.

[c] Geology of the Wichita Mountains: Bull. Geol. Soc. America, vol. 11, 1900, pp. 127–141.

WORK OF THE UNITED STATES GEOLOGICAL SURVEY.

The writer, assisted by Mr. C. N. Gould and Mr. E. O. Ulrich, mapped the geology of the Wichita Mountain region in the latter part of the season of 1901. The land had been cleared of all improvements, except the occasional inclosures on the allotments to the Indians, preparatory to the opening of the country to homestead settlers. It was devoid of inhabitants outside of the few small towns, except occasional Indians and prospectors. Recently the quarter-section and section corners had been reestablished for the purpose of ready location of homesteads. This region, outside of the mountains, is an open and practically featureless plain, and the mountains are almost bare, so that conditions for rapid and accurate geologic mapping were very satisfactory.

With the assistance of Mr. Gould all the known igneous areas and the contacts between the igneous masses and the formations of stratified rocks were mapped by traverse surveys, checked by locations on section and quarter-section corner stones.

Mr. Ulrich devoted his time to a study of the Cambrian and Ordovician rocks. An abundant collection of fossils gave means by which the rocks were correctly classified, as well as correlated with the Cambrian and Ordovician formations of the Arbuckle Mountains. The lithologic similarity of these rocks to the formations of the Arbuckle region, and the duplication of fossil remains, are so nearly complete that faunal lists of the Cambrian and Ordovician of the Wichita Mountains are not considered necessary.

PHYSIOGRAPHY OF WICHITA MOUNTAIN REGION.

The Wichita Mountain region consists of collections of mountains, hills, and knobs extending from Fort Sill, in the Apache Indian Reservation, northwestward to beyond Granite, in Greer County, Okla., a distance of 65 miles. From the vicinity of Fort Sill the northern and southern limits of this peculiar collection of mountains diverge until, near the center, the outlying knobs upon each side are 30 miles apart. Continuing northwestward the range gradually contracts and ends in small collections of low mountains or knobs northwest of the town of Granite. The region is thus symmetrical in general outline, but not so in the arrangement, size, and form of the mountains which constitute the range, or, more properly speaking, the groups of mountains. The groups of mountains composing the range with one exception, many of the individual mountains, and numerous knobs and points of granite and other igneous rocks are surrounded and separated by the nearly level and smooth plain of the "Red Beds" which extends southward across Oklahoma into western Texas.

WICHITA MOUNTAIN GROUP

The largest of the groups of mountains that compose the Wichita Range is the Wichita group, from which the range has received its name. It extends from near the northwest corner of the Apache Reservation northwestward about 25 miles, and consists of many rugged and irregular granite mountains, the most prominent of which are Mounts Scott and Baker, near the southeastern and northwestern ends, respectively. On Pl. III is a view of the southeastern part of this group from the plain of Medicine Creek, looking toward the southwest, and showing Mounts Scott and Sheridan. Mount Sheridan is about 4 miles west of Mount Scott. Between Mount Sheridan and Mount Baker and Haystack Mountain, at the west end of the group, are many unnamed mountains and peaks of sharp outline, separated by narrow, rugged passes. On Pl. IV, *B*, is a view of the northwestern end of the Wichita group, showing the sharp, serrated outline of the mountain crest. Near the source of Medicine Creek an arm of the Wichitas extends northward, ending in Saddle Mountain. Saddle Mountain is separated from the main Wichita group by a low pass, which is traversed by one of the large branches of Medicine Creek. Though the highest peaks in this group rise to elevations not exceeding 1,500 feet above the bordering plain, they are difficult of ascent because of the steep and rugged slopes, which are strewn with large angular granite bowlders.

The Wichita group of mountains is separated from the Quana Mountains on the south by a wide, plain-like valley, which descends with very easy grade from Military Pass, 2 miles east of Oriana, to the western end of the Carlton Mountains.

where it divides, the northern arm passing down a branch of Medicine Creek between Carlton Mountains and Mount Scott, while the southern arm extends to the plain down Beaver Creek. The sources of West Cache Creek occupy the western half of this valley and flow southward through gorges near the middle of the Quana Mountains.

This intermontane valley, like most other valleys of large size in the Wichita Mountain region, was formed during the deposition of the "Red Beds," of presumably Permian age, and has been resurrected and to some extent modified by more recent degradation. Many remnants of the "Red Beds" conglomerate yet remain in this valley between the present shallow drainageways from Military Pass at the head of the valley and the plain to the east upon each side of Carlton Mountains. From the same pass a wide embayment, partially filled with conglomerate and red clay deposits, opens southwestward, descending 200 feet or more to the general level of the plain about Oriana.

QUANA MOUNTAIN GROUP.

The Quana group, like the Wichita, is an elongated collection of granite mountains and low peaks about 14 miles in length. Though like the Wichita group in character of rock and topographic features, the individual mountains are lower, and none of them, it is believed, rise more than 800 feet above the general level of the plain bordering the mountains upon the south. The Quana group is separated into an eastern and a western part by gaps near the center, through which the three branches of West Cache Creek flow. The two westernmost and largest branches cross the mountains in narrow and deep gorges, while the other traverses an old, wide, and flat valley that originated contemporaneously with the intermontane valley which lies north of the Quana Mountains and with which it is connected. Remnants of the "Red Beds" conglomerates and red clay deposits may yet be seen in the floor of this valley.

CARLTON MOUNTAIN GROUP.

The Carlton group consists of low mountains and peaks which lie between the east ends of the Wichita and Quana groups and extend eastward to within a mile of Fort Sill. The topographic features of the Carlton Mountains are markedly different from those of the Wichita and Quana mountains. The Carlton Mountains consist of granite-porphyries and old rhyolites, which, unlike the granite, break into small angular bowlders and fragments upon weathering, giving rounded and comparatively smooth topographic forms. The general effect is like that produced by a topographically young region composed of homogeneous soft rocks—mountains composed of numerous ridges and spurs separated by V-shaped valleys.

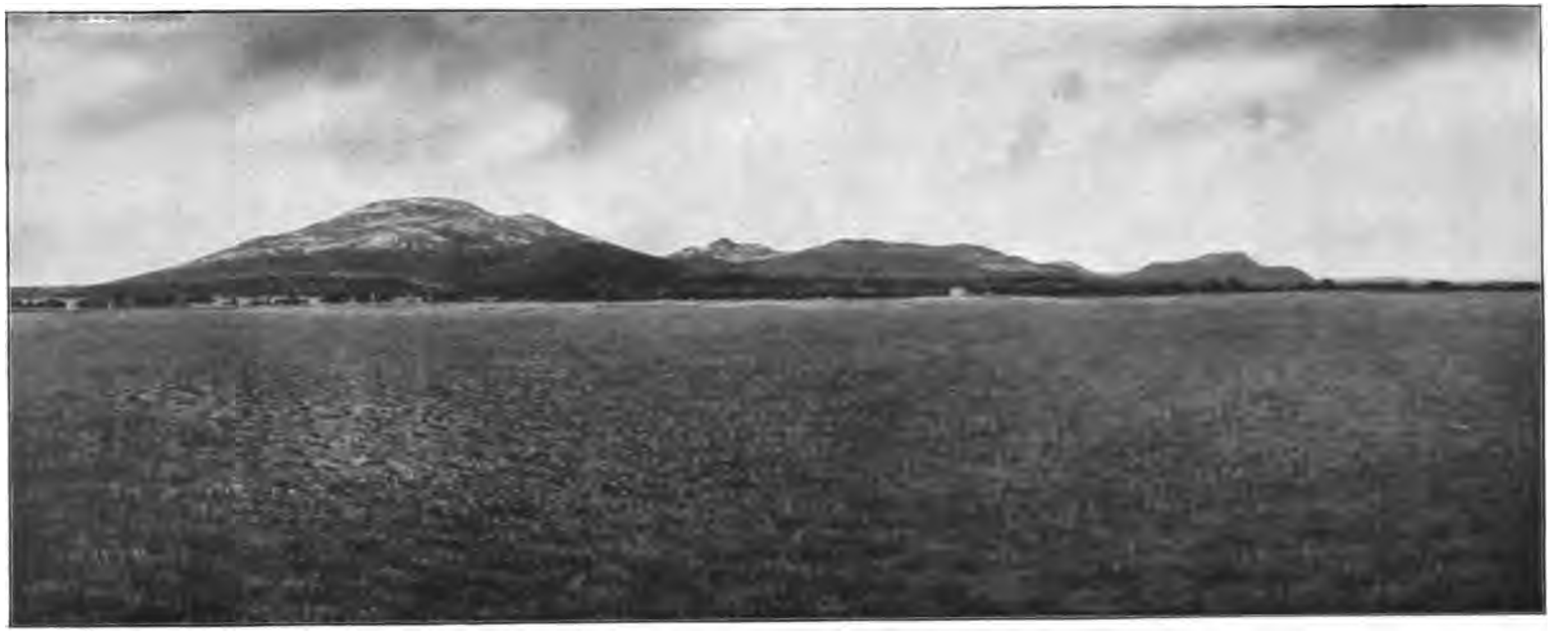
The outline of this group, as well as of its separated members, like that of all the other groups of the region, was established by marine degradation at a time when the Permian sea stood with its shores at the approximate position of the "Red Beds" and porphyry contact.

From near the center of the group an arm projects southward and ends in Signal Mountain, the highest peak, which rises about 800 feet above the plain. A single mass of hills is separated from the main group on the southwestern side by an inlet of the "Red Beds" plain which extends up the valleys of Wolf Creek and joins the broad upland valley between the Quana and the Wichita mountains. The most noteworthy feature of the Carlton Mountains is Medicine Bluff, at the extreme east end, about a mile west of Fort Sill (see Pl. III). Here Medicine Bluff Creek flows against the north side of the porphyry mountain, making perpendicular bluffs 100 to 400 feet high and about half a mile long.

RAGGEDY MOUNTAINS.

West of the Wichita and Quana mountains and extending southwest to Navajoe, in the valley of the North Fork of Red River, is a scattered group of mountains and hills, the individuals of which are separated by the "Red Beds" plain. To this group the name of Raggedy Mountains has been applied. Twin and Navajoe mountains, in the southwestern part of the group, are the only mountains to which names had been given when the region was surveyed in the fall of 1901. Contrary to the arrangement of the Wichita, Quana, and Carlton groups, which have northeast-southwest bearings governed in a measure by the structure, the Raggedy Mountains are longest north and south, an arrangement which seems to be accidental. Between the Wichita-Quana group and the Raggedy Mountains the flat plain is unobstructed. While gabbro rocks come to the surface across this plain and connect the gabbro of the central mass of the Raggedy group with the Wichita, they were completely worn down and submerged in Permian time and stand now in the level of the smooth "Red Beds" plain. Southwest from the Quana Mountains there is a broken string of granite knobs and hills connecting with the south end of the Raggedy group.

The central mass of the Raggedy Mountains is composed of gabbro, and is the only area of this rock exposed in the region which has not been reduced almost to the present level of the "Red Beds" plain. These mountains of gabbro lie east and southeast of Roosevelt, on both sides of Otter Creek. That part of the gabbro area of the Raggedy group south of Roosevelt and a fringe around the more mountainous part are practically in the level of the plain and contain thin patches of the "Red Beds" deposits, a remnant of the strata which once extended over the whole reduced portion. Here and there in the reduced gabbro areas are mounds and low rounded knobs which have not been affected by recent active



NORTHEASTERN FACE OF THE WICHITA MOUNTAINS.

Showing Mounts Scott and Sheridan.

erosion. The highest gabbro mountains lie on each side of the Upper Narrows and rise to elevations of 600 to 800 feet above the level of the plain. Iron Mountain is a knob in an arm of gabbro extending northeast of the Upper Narrows and is cut off from the mountain mass by a wide, flat divide. The detached elongated area east of Roosevelt makes low rounded hills 100 to 200 feet in height.

On disintegrating the gabbro breaks into bowlders in a manner similar to the granite, but they are generally smaller and rounded and give rotund topographic forms similar to the porphyry topography of the Carlton Mountains.

The northern and southern parts of the Raggedy group are composed of isolated granite mountains and knobs set in the smooth "Red Beds" plain. Many of the smaller ones rise abruptly 100 feet, more or less, above the red sediments of the plain, with evenly curved boundaries and steep sides, and have the appearance of nearly submerged peaks. In fact, they were islands in Permian time, and many—probably all—were submerged. There is no reason to doubt that these isolated areas, as well as mountain groups of igneous rocks, are connected beneath the "Red Beds" and formed peaks and knobs of a single broad range which were partly or wholly submerged and separated by the Permian sediments.

A peculiar feature of the Raggedy Mountains is that Otter Creek flows across the central part of the group and has cut through the more rugged gabbro and granite mountains, making narrow, sharp gorges known as the Upper and Lower Narrows. One of the large branches of this creek rises in the northernmost group of granite hills and flows across the gently rolling plain and passes the sharp gorges of the Narrows, 100 to 200 feet in depth, cut in wider divides which separate the higher knobs or peaks of the mountains. The only inference apparent at this time concerning the peculiar course of Otter Creek through the Raggedy group is that it occupied practically its present location at a time when the surface of the "Red Beds" plain stood above the divides between higher knobs of the igneous mountains in which the gorges of the Upper and Lower Narrows are cut. At that time the plain was nearly 200 feet above its present position, and as general degradation of the land progressed, Otter Creek was imposed upon the gabbro and granite masses which constitute the present Raggedy Mountains.

DEVILS CANYON GROUP.

The watershed between Elk and Otter creeks is a low and almost imperceptible swell in the plain. This divide separates the Raggedy Mountain group from the considerable collection of granite mountains and hills, including Little Bow, Elk, Dome, Teepee, Quartz, Suttles, and Devils Canyon mountains, besides many unnamed mountains and hills, which may be known as the Devils Canyon group.

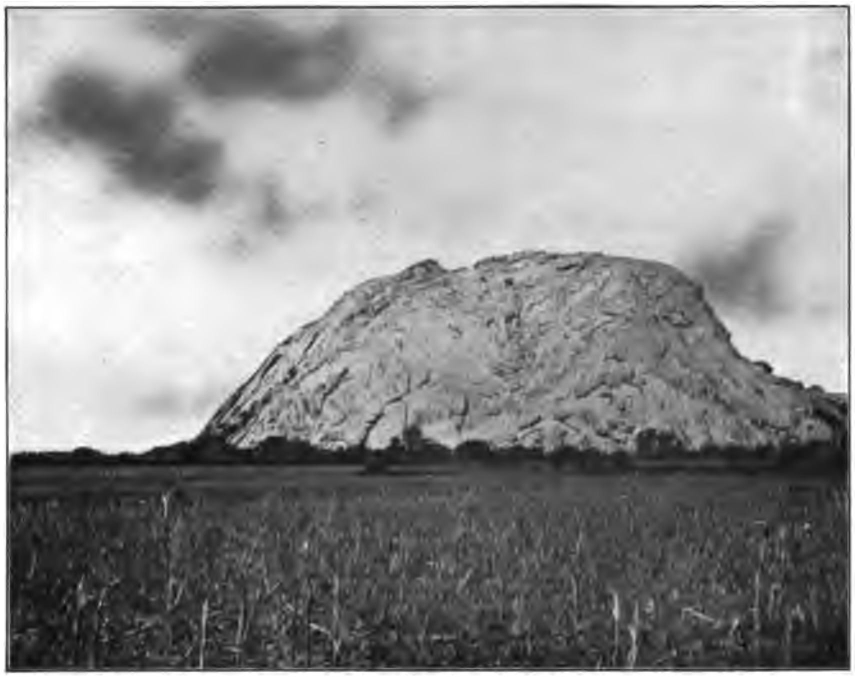
These mountains lie in the valley of the North Fork of Red River, and the channel of the river meanders among them, touching a number of the larger ones. The Devils Canyon group is composed almost entirely of granite, which protrudes through the "Red Beds." The rock is the same kind as that of the Wichita and Quana mountains and presents the same topographic forms. The smaller mountains and isolated knobs rise abruptly from the plain, their steep slopes being strewn with angular bowlders. The larger masses of granite, such as Quartz, Dome, and Devils Canyon mountains, contain many rounded knobs and peaks, rising 600 to 800 feet above the plain and separated by rugged gulches or divides. Many of these crests are dome shaped. This form was especially noted in Teepee and Dome mountains. In Dome Mountain the dome-shaped knob of the crest, 100 feet or more in height, sits 300 to 400 feet above the plain on a wide terrace or table of the mountain. On Pl. IV, *A*, is a view of the southwestern peak of Quartz Mountain, illustrating the abrupt ascent from the level plain and the forms of the isolated knobs in the western part of the Wichita region.

HEADQUARTERS MOUNTAIN GROUP.

At the extreme northwestern end of the Wichita Range is a small group of granite mountains which lie entirely west of Red River and northwest of the town of Granite. The largest of these is Headquarters Mountain, which covers an area of nearly 3 square miles and rises steeply to an oval crest about 600 feet above the plain. These mountains are composed of red granite similar to that of the Wichita group, but the mountain peaks and knobs have a rounded form, though the slopes are strewn with large bowlders.

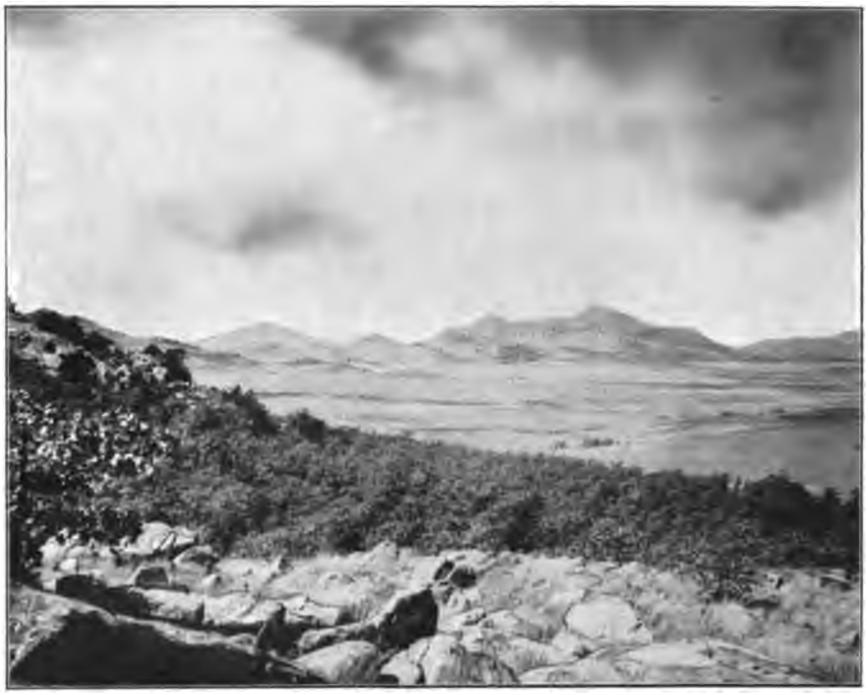
LIMESTONE HILLS.

Another mountain group of the Wichita region is the elongated collection of limestone and porphyry hills and low mountains which lies northeast of the Wichita group and is separated from it by a long strip of rolling plain 2 to 6 miles in width. This group, which has received no adequate name, extends from a point 7 miles north of Fort Sill northwestward, with the general strike of the rocks, to Rainy Mountain at Rainy Mountain Mission. It gradually expands in a rudely triangular form and reaches a width of about 7 miles in the central part. Near the middle, north of Mount Scott, the compact mass of hills is divided into two portions by a broad, flat inlet of the "Red Beds" deposit of the plain. Each of these arms is broken northeast of Saddle Mountain into numerous low mountains or hills, which are oriented generally northwest-southeast, with the trend or strike of the rocks. The northern arm contains a number of porphyry hills. A mass of porphyry also occurs between the limestone hills north of



A. SOUTHWESTERN KNOB OF QUARTZ MOUNTAIN.

Showing abrupt ascent of granite from the level plain.



B. NORTHWEST END OF THE WICHITA MOUNTAINS.

Showing sharp mountain crests and embayment of "Red Beds."

Mount Scott. The detached masses of limestone and porphyry are surrounded throughout this region by the open and level "Red Beds" plain.

The topographic details of the porphyry hills in this group are of the same character as in the porphyry hills composing the Carlton Mountains. The surface is broken and cut by many gulches and sharp defiles, but the hills are generally smooth crested and have rounded or oval forms.

The limestone hills have the same topographic features as the porphyry hills, and many of their crests are now 400 to 600 feet above the plain. Pl. V, *A*, shows a typical knob of Ordovician limestone near Rainy Mountain Mission, at the extreme western end of the limestone hills, known as Rainy Mountain.

Like all the other mountains of the region, the location, general plan, and contour of the hills are due to a cycle of degradation culminating in Permian time and to later minor modifications. The larger valleys descending from the more prominent limestone and porphyry hills, as well as the broader level passes of the plain which separate them, are not always occupied or followed by the principal drainage lines. These larger valleys and passes do not contain extensive deposits of recent local conglomerates, which might be supposed to extend as fans or sheets out from the mouths of the valley. The deposits of conglomerate descend or extend into the plain, blending with the red grits and clays and forming parts of the plains materials. The partly consolidated gravel, sand, and clay which filled the old valleys are softer than the crystalline limestone and porphyry now making the hills, and they were therefore more rapidly eroded and the old valleys were resurrected and are perpetuated. Many of the streams are small, but when established in their positions in the once submerged and filled valleys, as the general degradation of the land progressed, they cut downward without regard to the older and harder rocks. Thus many of the streams once flowing in the softer rocks became imposed upon the spurs and slopes of hard limestone bordering the old valleys. Marked instances of such superimposed drainage occur in Tps. 4 and 5 N., R. 12 W., where small streams, flowing in the wide resurrected valleys whose floors are filled with "Red Beds" deposits, cut through sharp spurs projecting from the limestone hills, while the level plain upon soft rocks was opened for their passage.

STRATIGRAPHY OF WICHITA MOUNTAINS.

IGNEOUS ROCKS.

In the general survey of the Wichita Mountains only sufficient time was available to study the salient features of the igneous rocks. The kinds of igneous rocks which occur abundantly or in large masses were distinguished, classified in respect to age as far as conditions would permit, and mapped. Local variations of the larger masses and various phases of the dike rocks were noted and specimens collected, but a study of their relations in detail was not attempted. The rocks collected were submitted to Mr. Ernest Howe, of the Geological Survey, for study, and the petrographic descriptions are from his report.

The igneous rocks of the Wichita Mountains are separated into four general classes, distinguished by their large mass or abundant occurrence, and also by their age relations. These, in order of apparent age, are, gabbro and related anorthosite, granite and related aplites, granite-porphyry and associated aporhyolite, and diabase dike rocks.

GABBRO AND RELATED ANORTHOSITE.

For the most part the gabbro is exposed in valleys or in the plain which surrounds the mountains. Such is its occurrence along Medicine Creek southeast of Saddle Mountain, in the broad elevated valley between the Wichita and Quana mountains, and in the plain between the Wichita and Raggedy mountain groups. On the southern side of Medicine Creek the gabbro rises in the lower northern slopes of the Wichita Mountains beneath the granite. The position of the gabbro with regard to the granite is similar on the southern and western sides of the Wichita group. On the north and south the gabbro of the Raggedy Mountains is separated from the granite masses by the "Red Beds" deposits, but in the plain eastward it is connected with the gabbro of the Wichita group.

The gabbro of the Raggedy group makes mountains of considerable size, but their general aspect is different from that of the mountains formed of the granite. The gabbro disintegrates more readily, and even the large-size bowlders are less angular than those of granite. The general effect is a roundness of contour and profile of the hills, and in the valleys or plain the rock is generally disintegrated.

The prevailing physical aspect of the gabbro is that of a dark-gray to black, rather coarsely crystalline, rock. The gabbro proper consists of labradorite, augite, and magnetite with a little biotite and accessory titanite. It is a typical gabbro, fairly fresh, or with the augite altered to uralitic hornblende.

The rocks which on close study have proved to be anorthosite were collected as phases of the gabbro, and occurred near the contact with the granite or near dikes of granite or aplite. Between the anorthosite and the gabbro a continuous gradation can be made out, even in hand specimens. The specimens of anorthosite collected show a reddish, greenish, or bluish-gray rock, with lath-shaped crystals of labradorite.

Petrographically the relation between the gabbro and anorthosite rocks is close, and in the field it is doubtful if lines can be drawn separating them. In the several specimens of anorthosite examined, labradorite is the only constituent.

A. RAINY MOUNTAIN, AN ORDOVICIAN LIMESTONE KNOB IN THE "RED BEDS" PLAIN.

B GRANITE BOWLDERS IN THE EAST SLOPE OF MOUNT SCOTT.

with the exception of a mere trace of magnetite. Beginning with a faint trace, the augite increases in quantity until it is almost equal in amount to the labradorite. With the increase of augite or its alteration product, uralitic hornblende, there is a corresponding increase in the magnetite. The various stages can be readily seen.

GRANITE AND ASSOCIATED APLITE.

Granite is the principal mountain-making rock in the Wichita region. Its area is greater than that of all the other igneous rocks combined, and is about equal to that of the others and the older Paleozoic sediments. It makes all of the high land of the Wichita, Quana, Devils Canyon, and Headquarters mountains, and a large part of the Raggedy group.

The relations of the granite to the gabbro indicate that the granite is younger and that it intrudes the gabbro. Both occur in large masses, as shown, and the gabbro is cut by a great number of granite or aplite dikes, which in many cases can be traced from the granite mass.

In physical aspect this granite varies from dark red to light pink and from moderately coarse to finely granular. A representative of a large part of the granite mass is found in Mount Scott, which consists of a rather deep-pink, even-textured, and moderately fine-grained rock.

The granite in its various phases is rich in orthoclase and quartz, with relatively subordinate amounts of the dark silicates, hornblende, augite, or biotite. The majority of the specimens studied are from dikes cutting the gabbro or very near the contact of the granite with the gabbro. A specimen from the top of Mount Scott may be taken as typical of the granite as a whole. It is a medium coarse-textured rock, to which the feldspar gives a dominant red color, which is varied by small spots of a dark-greenish mineral and grains of quartz. The microscope shows that orthoclase and quartz occur in nearly equal amounts and together make up by far the greater part of the rock. A little hornblende also occurs, and accessory magnetite, apatite, and zircon. Although not evident in hand specimens, the rock is seen to have a crude porphyritic structure when examined under the microscope. The feldspar occurs in large phenocrysts, surrounded by quartz and feldspar in micropegmatitic intergrowths. The dark, turbid character of the feldspar is to be attributed to finely divided hematite which fills the crystals as a dust.

Parts of the large granite masses also show variations in texture. In the northwestern foothills of Saddle Mountain the granite has a finer texture and is porphyritic, but is slightly different from that occurring commonly in the Carlton Mountains. A similar phase of the granite occurs in the northwestern hills of the Headquarters group, at the extreme northwestern end of the Wichita Range.

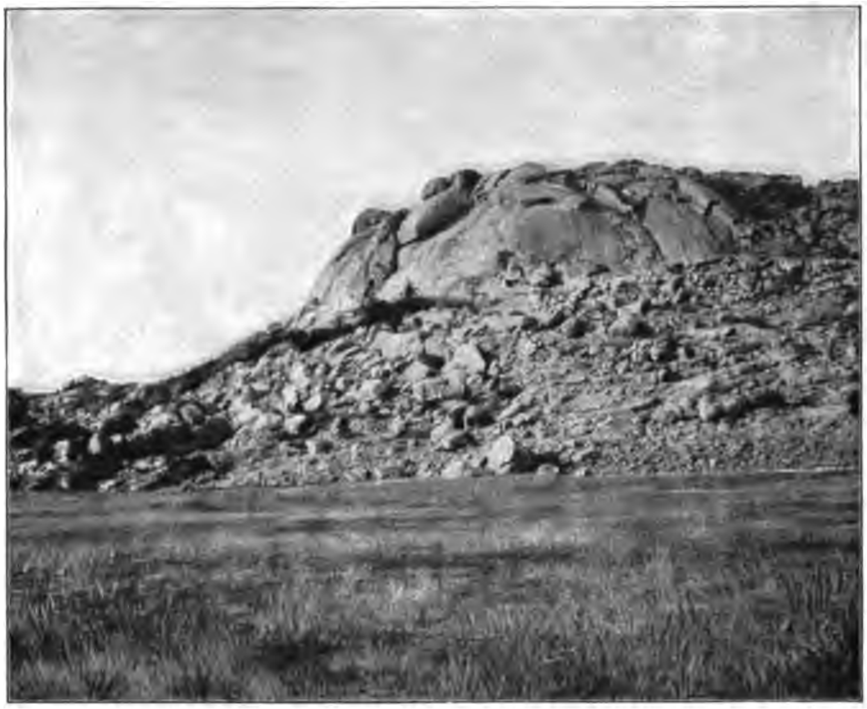
Variations of the granite from the average type are found chiefly near its contact with the gabbro. A particular instance was noted in the SE. ¼ sec. 21, T. 4 N., R. 14 W., where the granite mass rests against the gabbro. Hand specimens show the rock to be strongly porphyritic, and it may be called spherulitic granite-porphyry. A similar contact phase of the granite with gabbro occurs near the center of the south side of sec. 16, T. 4 N., R. 14 W.

The dikes which extend from the granite and cut the gabbro range from massive bodies 40 feet and more in thickness to thin sheet and stringers. Usually the rock of the thicker dikes is coarser and is more nearly related to typical granite than the rock of the thin dikes. A dike, 40 feet in width, cutting the gabbro in the SE. ¼ sec. 4, T. 4 N., R. 13 W., is characterized as an augite-hornblende-granite. The dikes generally, however, are best described as aplites. They are fine-grained rocks, in gray, pink, and lighter colors. Quartz and feldspar occur in the usual fine mosaic characteristic of aplites. The feldspar is predominantly orthoclase, plagioclase being present only in very small amounts. Augite, hornblende, and biotite occur, but never prominently; muscovite is rarely present, and the usual accessories of granite, magnetite, titanite, apatite, and zircon are generally found in small amounts.

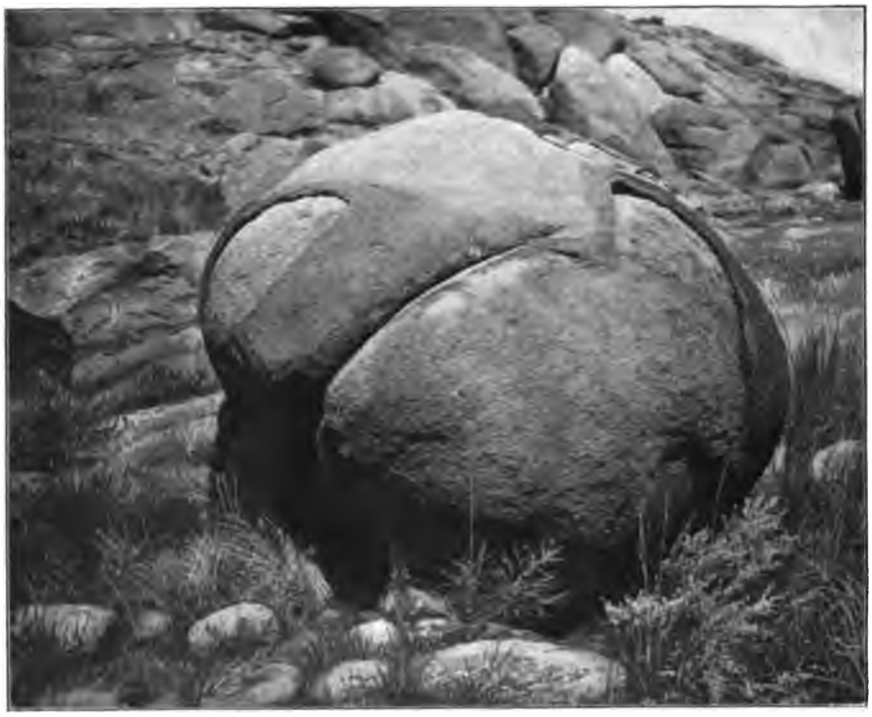
The contact between the granite and granite-porphyry is exposed south of Mount Scott for a few miles. To the west, across secs. 22 and 23, T. 3 N., R. 13 W., the contact between the granite and porphyry can be traced, although the contrast in the rocks on each side is not strong, as the two rocks are practically the same in color and in granular texture. Apparently, also, there is a gradation through a short space from the granite to the granite-porphyry. Along the eastern part of the contact, in parts of sec. 24, T. 3 N., R. 13 W., and farther east, a wide band of finely granular aplite occurs between the granite and the granite-porphyry.

In the description of the structure of the Wichita Range it was observed that there are zones of fracturing and jointing in the granite. In such localities the rock on weathering breaks up into relatively small, angular bowlders. The prevailing surface features of the granite, however, are coarse and rugged, the rocks having broken deeply into large angular bowlders between widely set joints, and become rounded on long weathering. The slopes of Mount Scott are typical of the granite surface of large masses. (See Pl. V, *B.*) The lower slopes of the knobs and mountains are strewn with immense bowlders, many of which descend to the borders of the plain. The large bowlders become well rounded on long surface exposure, and some of these in old age are reduced by exfoliation. A typical example of this peculiar mode of weathering occurs at the southern side of Quartz Mountain, and is shown in Pl. VI, *B.*

In the western part of the Wichita Range many of the low mountains and



A. EXFOLIATE WEATHERING OF GRANITE MOUNTAIN 3 MILES NORTHWEST OF SNYDER.



B. EXFOLIATE WEATHERING OF GRANITE BOWLDER, SOUTH SIDE OF QUARTZ MOUNTAIN.

knobs have dome-shaped or oval crests. The centers of some of these show large masses of granite but little broken. A typical knob of this character may be seen in one of the crests of the granite mountains of the Raggedy group in sec. 22, T. 3 N., R. 17 W. On long exposure the massive granite knob has assumed exfoliation on a large scale. From the plain on the southwestern side large segments of granite, many feet thick, may be seen becoming detached from a spheroidal dome. This view is illustrated on Pl. VI, *A*.

GRANITE-PORPHYRY AND ASSOCIATED APORHYOLITE.

A class of rocks apparently closely related to the granite composes practically all of the Carlton Mountains, the igneous mass lying between the limestone hills in the vicinity of Blue Canyon, north of Mount Scott, and some hills near the northwest end of the limestone areas east of Rainy Mountain Mission. They vary from brick red to shades of light pink. The porphyritic character is variable, and specimens may be selected which have a near resemblance to certain parts of the granite, but on the whole the masses designated granite-porphyry are different from those described as granite.

Megascopically the rock appears to be a rather coarse-grained and largely feldspathic porphyry. With the exception of the feldspar phenocrysts, there seem to be usually no real crystal grains, the remainder of the rock consisting of a dense felsitic groundmass. Rarely a specimen is found which shows occasional small quartz grains. A microscopic examination shows that, with the exception of a very little altered hornblende, the rock is composed almost entirely of spherulitic aggregates of feldspar and micropegmatite, often grouped about small crystals of feldspar. A little quartz also occurs, in grains.

In some instances the feldspars have a faint zonal structure, but these and a small proportion of the others, presumably plagioclase, are undeterminable on account of their decomposition. The greater part of the feldspar is orthoclase. The above description applies to the rock of Carlton Mountain, on Medicine Creek, near the western side of sec. 28, T. 3 N., R. 12 W.

Another porphyry, distinct from that just described, is found in the east end of the Carlton Hills, at the east end of Medicine Bluff. It is a dull-pink rock, with phenocrysts of feldspar and quartz, in a dense or finely granular groundmass. The feldspar phenocrysts are all orthoclase, frequently twinned according to the Carlsbad law, and from 3 to 4 millimeters in length. The groundmass, largely feldspathic, and in part possibly micropegmatitic, is now very much decomposed, and looks not unlike the devitrified base of a surface glassy flow. With the exception of a little doubtful hornblende there are no dark silicates to be made out. The feldspars are all charged with a fine reddish dust, probably hematite.

In Blue Creek Canyon, sec. 11, T. 4 N., R. 13 W., a rock is exposed which plagioclase seemed to be as basic as labradorite. The relations of the two feldspars vary somewhat, but orthoclase is generally slightly in excess. In all specimens quartz occurs, but never in great abundance. It is usually in the form of pegmatitic intergrowths with orthoclase. Hornblende and accessory biotite, though seldom fresh, are present in all the rocks, frequently in abundance. Accessory minerals are inconspicuous.

QUARTZ VEINS OR DIKES.

The large igneous masses above described contain here and there veins or dikes of white quartz. Probably the most extensive deposits of quartz occur in nearly east-west leads in the central part of the gabbro area of the Raggedy Mountain group. Quartz bands were noted by Dr. H. F. Bain in the granite of the Quana Mountains in the valley of the stream which flows south through sec. 35, T. 3 N., R. 14 W. Quartz bands were found also in a small gabbro hill in the southeast corner of sec. 6, T. 4 N., R. 18 W., near a large granitic dike which cuts the gabbro in an east-west direction. Like the diabase dikes, the quartz bodies extend both across and in the direction of the trend of the Wichita Range. It has been reported by Doctor Bain[a] that some of the quartz veins are granular and contain mica, and that a large one cutting the granite-porphyry of the Carlton Mountains at Medicine Bluff is intersected by a diabase dike.

It has been shown that the granite-porphyry and the diabase dikes which intrude it were formed prior to middle Cambrian time. The relations of quartz bodies and diabase dikes in the Carlton Mountains and the granular structure of the quartz suggest strongly that at least one of the quartz bodies is a true dike and not a vein deposit.

GRORUDITE.

Two dikes of peculiar nature, cutting gabbro, were located, one in the SE. ¼ sec. 4, T. 3 N., R. 15 W., and the other near the center of sec. 9 of the same township. The first is 4 to 6 inches thick and cuts a large gabbro mass near the contact with the granite, toward which it bears. The other is 18 inches to 2 feet thick and occurs in the same gabbro area, but at a point where the gabbro is less than one-fourth of a mile in width and is bounded on each side by granite. As in the first instance, the dike bears across the gabbro and toward the granite. In neither case, however, could the dikes be traced into or connected with the granite on account of the disintegrated and bowldery nature of the latter near the bases of the hills at the contact with the gabbro. While the general bearing of the larger dike is east-west, it appears to have been folded or distorted. It curves in different directions, and inclines at various angles, from nearly flat to a vertical position.

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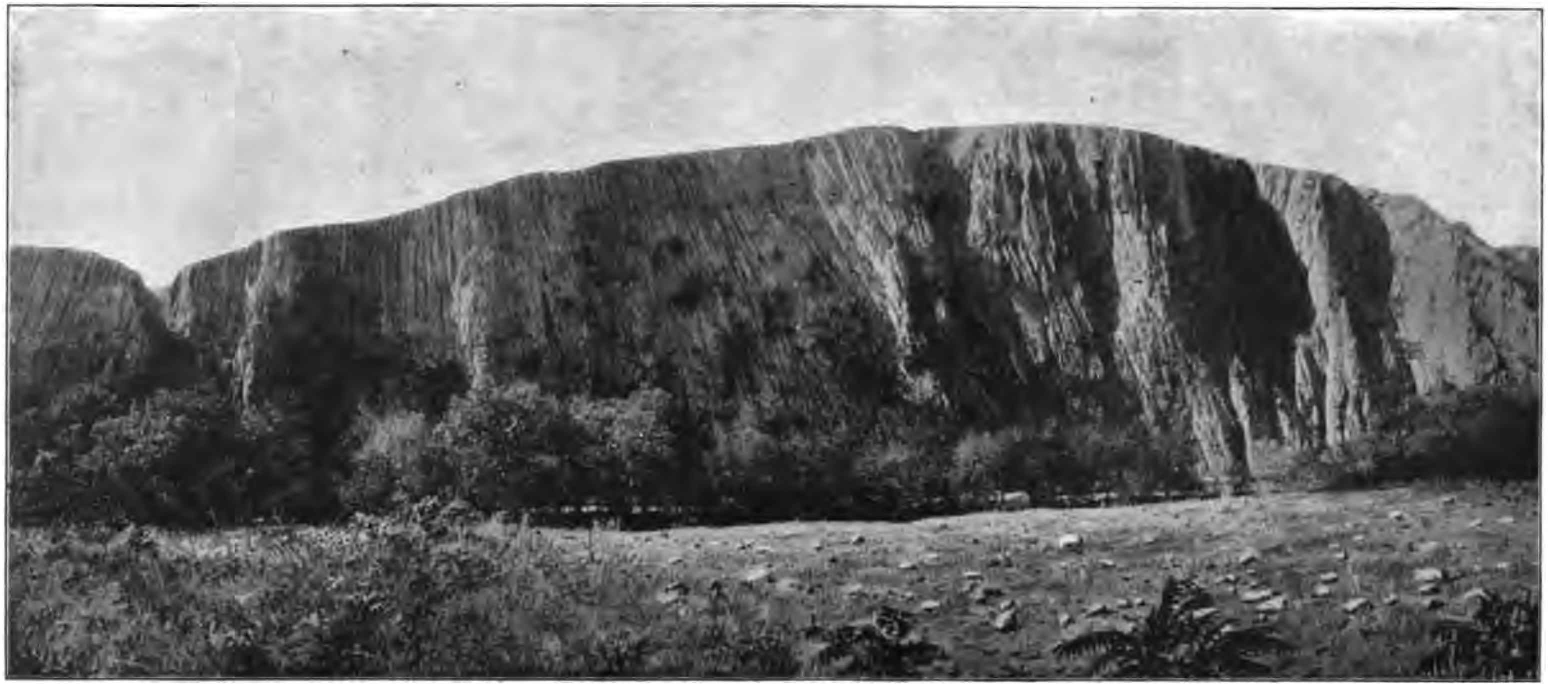
[a] Geology of the Wichita Mountains: Bull. Geol. Soc. America, vol. 2, 1900, pp. 127-144.



MEDICINE BLUFF, NORTH SIDE OF CARLTON MOUNTAINS.

This dike rock is reddish to greenish gray, and granular in texture. Usually on each side near the contact it is coarsely crystalline and resembles pegmatite in structure, while toward the center it becomes by degrees finely granular; and with the variation in structure there is a gradation from light to dark colors, giving the dike a rudely banded, vein-like appearance.

On microscopic examination it is found that a large amount of quartz and feldspar in irregular masses is penetrated by elongated crystals of a nearly black ægirite. There is a rapid transition between the coarse border and the interior, which is very fine textured and in which individual crystals can not be distinguished by the unaided eye. The prevailing color of the interior is dull green. Another portion in an intermediate position is a little less finely grained, and individual crystals can be made out in hand specimens. This has a slightly different composition from the rest, and the relation of the two is not clear. Under the microscope the rock is found to be composed of quartz, feldspar, and ægirite. The different occurrences show slight variation in the character of the feldspar, but the average is orthoclase and microperthite or microcline-microperthite in nearly equal proportions, with albite and some anorthoclase. Quartz follows the feldspars in the importance of its occurrence. Ægirite is abundant, and is fresh and typical in appearance. It occurs in crystals one-half to three-fourths of an inch long in the border zone, and in fine acicular needles or mesh-like aggregates surrounding the grains of feldspar and quartz in the interior of the dike. It has the appearance of having been developed later than the feldspars. As well as can be determined from a microscopic examination, the rock is practically the same as the grorudite described by Brögger.[a]

A few specimens from different parts of the same dike would probably have nearly the same chemical composition as the rock described, but the soda-rich pyroxene appears in very subordinate amounts and its place has been largely taken by arfvedsonite. In other details the rock is also different from the grorudite. Albite in irregular laths is the most prominent feldspar, and with it is associated microperthite, but little or no orthoclase. Quartz is abundant, and the arfvedsonite, often intergrown with ægirite, is a most striking constituent. Ægirite is also found free from arfvedsonite, in needles and larger masses, but it is a distinctly subordinate mineral.

SEDIMENTARY ROCKS.

In the Wichita region and the Arbuckle Mountain region the formations below the "Red Beds" agree in all essentials, both in lithologic characters and in age, in so far as they are exposed, and are of essentially the same thickness.

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[a] Zeitschr. für Kryst., vol. 16, 1890, pp. 65–69; Eruptivgest. d. Kristianiageb., I, Grorudit-Tinguait Serie, pp. 46–48, Kristiania, 1894.

Therefore the classification and the formation names employed for the Arbuckle region are used also for the Wichita Mountains.

CAMBRIAN ROCKS.

Reagan sandstone.—The Reagan sandstone is the lowest Cambrian formation in the Wichita region, and it rests on the eroded uneven surface of the granite porphyry, from which most of its materials have been derived. The formation is known to outcrop in this region in but four areas. The largest of these lies on the northeastern side of the large mass of porphyry east of Blue Creek Canyon and is beneath the thick section of Cambro-Ordovician limestone, which follows in regular stratigraphic succession. The other three areas are near the northwestern end of the group of limestone hills, 8 to 12 miles northwest of and in the strike of the large area near Blue Creek Canyon. The same granite-porphyry either is exposed near by or is in contact beneath the Reagan sandstone and the Cambro-Ordovician limestones. Between these smaller outcrops of the Reagan sandstone, as well as in many other places where the succeeding limestone indicates that it should occur, the Reagan sandstone is concealed by the widespread "Red Beds" deposits. In all the occurrences cited the Reagan sandstone dips in a northeasterly direction and is so aligned in strike as to show, without doubt, that it is continuous beneath the "Red Beds."

In a part of the larger area east of Blue Creek Canyon the Reagan sandstone is repeated in parallel belts by faulting. The fault approaches the stratified rocks in the porphyry from beneath the "Red Beds," bearing nearly due northwest. The downthrow is toward the southwest, giving sufficient displacement to bring the whole section of the Reagan sandstone against the belt of porphyry which occurs between the duplicate outcrops of the sandstone. The displacement due to faulting decreases toward the northwest and comes to an end near the northwest corner of sec. 1, T. 4 N., R. 13 W. The normal dip of the rocks is toward the northeast, varying from a few degrees to about 25°. Next to the fault on the southwest or downthrown side there is a reverse dip, due to the upward flexing of the strata in the faulting, which is sufficient to produce a narrow synclinal fold a mile or more in length, ending in a spoon-like form, with porphyry upon each side and beneath. The Reagan sandstone is softer than either the porphyry beneath it or the succeeding Arbuckle limestone. In consequence it forms the base and northeast side of valleys, and forms bluffs and steep slopes in which the rocks are admirably exposed. The section accompanying the map illustrates the relations and structure of the rocks, including the Reagan sandstone, across the northeast corner of T. 4 N., R. 13 W. Pl. VIII, *A*, is a view of the Reagan sandstone and associated rocks in the NE. ¼ sec. 12, T. 4 N., R. 13 W., looking northwest. The porphyry upon which the Reagan sandstone rests is on the left, and the Arbuckle above the sandstone caps the mountain on the right.

The Reagan sandstone is approximately 300 feet thick and is composed of hard and soft sandstone, grit, conglomerate, shales, and siliceous shell limestones. The section of the formation is essentially the same as in the western end of the Arbuckle Mountains. In each case porphyry is beneath it, and the limestone which overlies the Reagan is of the same nature and contains the same fossil fauna. In both localities the Reagan formation is made up of conglomerate composed of porphyry pebbles and included basic rocks, gritty light-brown to gray and greenish sandstones, greenish clay shales, and siliceous limestones, interstratified. The limy layers contain many species of Cambrian fossils, which were carefully collected, but which have not yet been thoroughly studied. The conglomerate occurs invariably near the base as local beds or lentils, while the calcareous sandstone and limestone beds are without exception in the upper part of the formation.

From Blue Creek Canyon northwest toward Rainy Mountain Mission the Reagan formation should occur, in the natural order of succession, beneath the "Red Beds" plain, between the igneous rocks of the Wichita Mountain group and the limestone of the long ridges to the northeast. Southeastward of Blue Creek Canyon, beneath Fort Sill, and westward from Fort Sill, its stratigraphic position is between the porphyry of the Carlton Mountains and the limestone of the hills. These limestones are in the lower part of the Ordovician, and their southward dips indicate that the Reagan sandstone is concealed unconformably beneath the "Red Beds." The basal "Red Beds" grits outcropping at the eastern end of the Carlton Mountains resemble parts of the Reagan formation occurring east of Blue Creek Canyon. As the "Red Beds" grit is composed of porphyry material, and is for the most part a local beach deposit like the Cambrian sandstone, it is necessary to determine the relations of the individual beds to the succeeding strata in order to classify them.

CAMBRO-ORDOVICIAN ROCKS.

Arbuckle limestone.—Above the Reagan formation in conformable succession is a great limestone section essentially the same as the Arbuckle formation in the Arbuckle Mountains, where the lower part, practically the lower third, was found to be Cambrian, and the upper two-thirds Ordovician in age. Near the transition zone, between the rocks of the two periods, very few fossils have been found, so that precise distinctions as to age can not be made at the present time. The same conditions of deposition seem to have occurred in the Wichita region as in the Arbuckles, and the rocks must be classified in the same manner. There seems to be no reason to doubt that the formation is continuous from one region to the other beneath "Red Beds" deposits.

With the exception of three small areas near Rainy Mountain Mission, all the limestones found in the area mapped belong to the Arbuckle formation. There are certain thin limy strata in the "Red Beds" which do not resemble the older limestones and have not been mapped. The Arbuckle limestone is composed of a practically continuous succession of limestone beds, usually less that 5 feet in thickness and aggregating 4,000 to 6,000 feet. The individual beds vary from dense, fine-grained, white limestone to cream-colored dolomitic limestones interstratified with slightly argillaceous and siliceous lime beds, which are usually not so hard. Occasional cherty limestones, and more rarely thin beds of chert, occur. As a result of the variable hardness of the beds, the more resistant ores have a relief which rarely exceeds 5 or 6 feet. A complete section of the formation is not exposed in the region. The thickest exposure found is northeast of Blue Creek Canyon, where the rocks outcrop in regular succession from the base upward for nearly 3 miles. The dip is approximately 20° NE., and approximately 4,000 feet of this limestone are exposed. It is estimated that the same thickness is exposed in the long arm of limestone hills outcropping northwestward from Blue Creek Canyon. Neither the top nor the base of the limestone has been found in the hills west of Blue Creek Canyon. The lowest limestones exposed beneath the "Red Beds" at the southwestern side, however, are near the base and those of the northeastern side are toward the top.

The elongated limestone hills at the northeastern part of T. 5 N., R. 15 W., and in the southwestern portion of T. 6 N., R. 15 W., belong most likely below the middle of the section, as determined by the abundant fossil remains and by the position in the strike of the central part of the section exposed in the large limestone mass toward the southeast. Likewise the limestones occurring at the quarries southeast of Fort Sill, south of Signal Mountain, and farther west at the eastern end of the Quana Mountains, belong below the middle of the Arbuckle formation. The limestone in the hills south of Signal Mountain and farther west yields an abundant fauna of upper Cambrian and lower Ordovician age, closely related to that of the quarries at Fort Sill and of the limestone hills 3 to 6 miles southeast of Rainy Mountain Mission. The Arbuckle limestone north and east of the porphyry in T. 6 N., R. 14 W., is in the lower and middle part of the formation and belongs to the Cambrian and lower Ordovician parts of the section.

ORDOVICIAN ROCKS.

In the Arbuckle Mountains there is a formation 1,500 to 1,800 feet thick, composed of limestone, shale, and sandstone, known as the Simpson formation, which occurs between the Arbuckle and Viola limestones. The rocks of this formation are for the most part softer than the contiguous limestone upon each side, and are therefore more easily degraded and usually form low lands or valleys. In the Wichita region this formation, if it occurs, is entirely concealed by the "Red Beds" deposits which surround the Arbuckle and Viola limestone exposures. As far as can be determined from the exposures of the rocks which elsewhere occur above and below it, the Simpson formation, if the "Red Beds" were removed, would outcrop in an area extending northwestward from the north end of Blue Creek Canyon, passing just south of the porphyry areas in T. 6 N., R. 14 W., and the three Viola limestone hills south of Rainy Mountain Mission, in an area east of the group of limestone hills bearing northwestward from the vicinity of Richards switch; and in an area south of the isolated limestone hills west of Fort Sill. These references as to location are given because along the streams in some of these areas the "Red Beds" may have been eroded to a sufficient depth to expose the Simpson formation.

Viola limestone.—This formation, which occurs in full exposures throughout the Arbuckle Mountain region, is found here in three isolated areas, which form small rounded hills rising from the level of the "Red Beds" plain in the vicinity of Rainy Mountain Mission. They are in alignment, and extend northwest-southeast, in the general strike of the limestones of this region. The thickness of the formation, where it is known in the Arbuckle region, is 500 to 700 feet; but in the Wichita region only 200 to 300 feet of the middle portion are exposed. The formation is composed entirely of limestones, with occasional thin lentil-like bands and nodules of chert. Its lithologic character, including the chert, and the abundant Ordovician fauna, are practically the same here as in the Arbuckle Mountain country. According to its position in the section this limestone should occur beneath the "Red Beds" northeast of the group of limestone hills bearing northwestward from the vicinity of Richards, and also south of the eastern end of the Arbuckle limestone south and southwest of Fort Sill. The Viola formation is thinner and more easily eroded than the Arbuckle limestone, and as a result has been generally worn down to lower levels and concealed by the "Red Beds" deposits. Most likely it will not be found in the region beyond the limited areas near Rainy Mountain Mission.

In the Arbuckle Mountains the Viola limestone is succeeded by a soft, greenish shale formation termed the Sylvan shale. This is at the base of the Silurian, and is followed in turn by the Hunton limestone, which reaches to the Devonian. Above the Silurian is Devonian chert, which is succeeded by a very thick section of Carboniferous rocks. In the Wichita region all these rocks, so far as known, are concealed by "Red Beds" deposits. So far as can be judged from the structure of the Wichita uplift, the Silurian, Devonian, and Carboniferous rocks should occur successively farther away from the axial part of the range beyond the outcrop of the Ordovician strata.

CARBONIFEROUS ROCKS.

PERMIAN.

"*Red Beds.*"—In discussing the stratigraphy of the Arbuckle Mountains it has been stated that the "Red Beds" lap across the western end of the Arbuckle uplift unconformably, concealing the westward continuation of the folded strata, including Ordovician, Devonian, and Carboniferous rocks. From the western end of the Arbuckle uplift these "Red Beds" deposits are continuous westward to and around the Wichita Mountains, also northwestward into northern Oklahoma and Kansas, and southwestward into Texas.

From the Arbuckle Mountains westward, midway to the Wichita Mountains, the "Red Beds" dip slightly (less than 5°) toward the west. Still farther west, to and around the Wichita Mountains, the rocks are practically flat. In and near the Wichita Mountains the "Red Beds" have local variable but low dips away from the mountains, which were the old Permian land areas. These local structures are considered to be due to deposition of the sediments upon the sloping near-shore sea bottom rather than to post-Permian orogenic movements.

In the earlier part of the season of 1901 and at other times Dr. George I. Adams made some stratigraphic investigations concerning the age of the "Red Beds" in northwestern Indian Territory and eastern Oklahoma north of Canadian River. He observed[a] that the red color transgressed the strata diagonally from the upper part of the Pennsylvanian into the Permian. No indications of unconformity between the Pennsylvanian and Permian, or between other stratigraphic horizons, were noted by Doctor Adams. If there is no unconformity at the base of the "Red Beds" north of Canadian River, and if Doctor Adams's observations concerning the color of the strata are correct, the stratigraphic unconformity of the "Red Beds" across the Arbuckle uplift is local, though the uplift was profound and the erosion great from the beginning of the uplift through a large part of "Red Beds" time.

In this discussion no attempt will be made to distinguish by names or classify the various deposits which make the "Red Beds" except as to order of succession, since they were studied only across the western end of the Arbuckle uplift, along the section between the Arbuckle and Wichita Mountain regions, and in proximity to the pre-Permian rocks of the Wichitas, and since no fossils, except a few small fragments of bones which were not determinable, were found in them. The base of the "Red Beds" was traced across the upturned and eroded beds of Ordovician, Silurian, Devonian, and Carboniferous strata from the northern side of the Arbuckle Mountains southward nearly 30 miles. The "Red Beds" were observed to dip westward regularly at low angles. It has been explained that in the

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[a] The Carboniferous and Permian age of the Red Beds of eastern Oklahoma from stratigraphic evidence: Am. Jour. Sci., 4th ser., vol. 12, 1901, pp. 383-386.

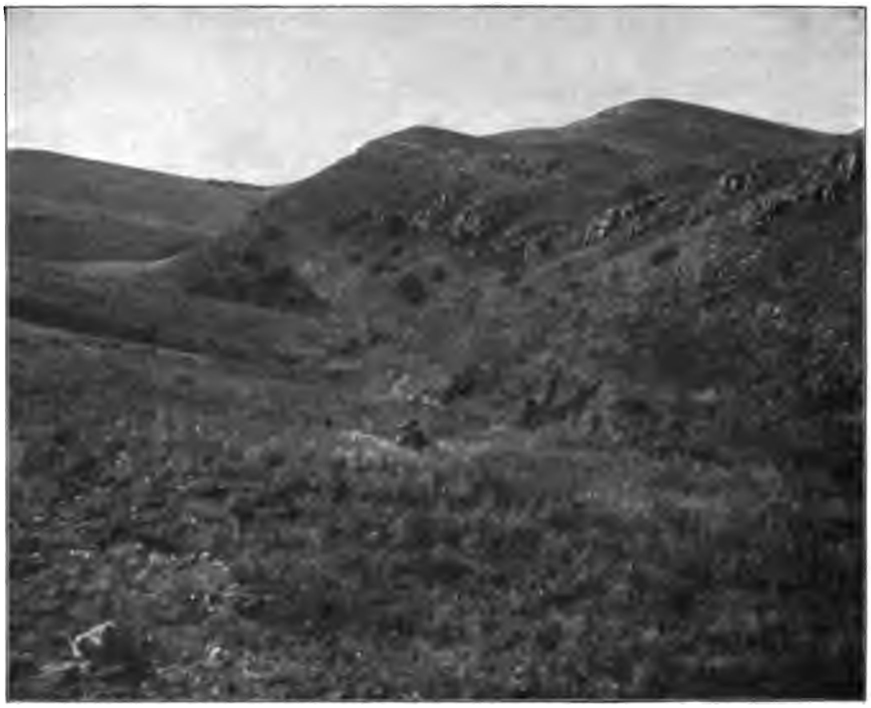
Arbuckle Mountain region the older rocks above the Cambrian dip steeply and at various angles toward both the north and the south, with strikes generally northwest and southeast.

In the section from the Arbuckle Mountains westward the "Red Beds" are naturally divided into three members, formations, or divisions, the extent of which toward the north and south has not been determined. The basal member, resting upon the upturned and eroded older rocks, varies in composition along the strike according to the character of the older rocks in the vicinity from which it was in large part derived. At the western end of the axial portion of the Arbuckle uplift, where limestones appear in contact with the "Red Beds," the basal conglomerate is composed chiefly of limestone pebbles derived directly from the degraded older Paleozoic rocks. These limestone conglomerates are interstratified with grits, greenish and red shales, and siliceous fragmental limestones, or fine limestone conglomerates, which have a total thickness of probably 200 feet. South of the axial portion of the Arbuckle uplift, where the "Red Beds" approach outcrops of Devonian chert and Carboniferous sandstone, the basal member is composed chiefly of cherty conglomerates interstratified with the greenish and reddish clays and soft sandstones. Still farther south, where the basal member rests only upon the Coal Measures sandstones and shales it is composed chiefly of soft sandstones and shales, with a minor amount of conglomerate. Above Carboniferous rocks these sandstones and shales of the "Red Beds" usually contain less red color than above the limestones and shales of the Ordovician and Silurian. As these coarse strata near the base of the "Red Beds" are followed westward they are found to continue for several miles before disappearing beneath higher sediments. In their extention westward the conglomerate element is found to decrease, the limestone conglomerates giving place to argillaceous tough limestone beds associated with the same green and red shales, grits, and soft sandstones.

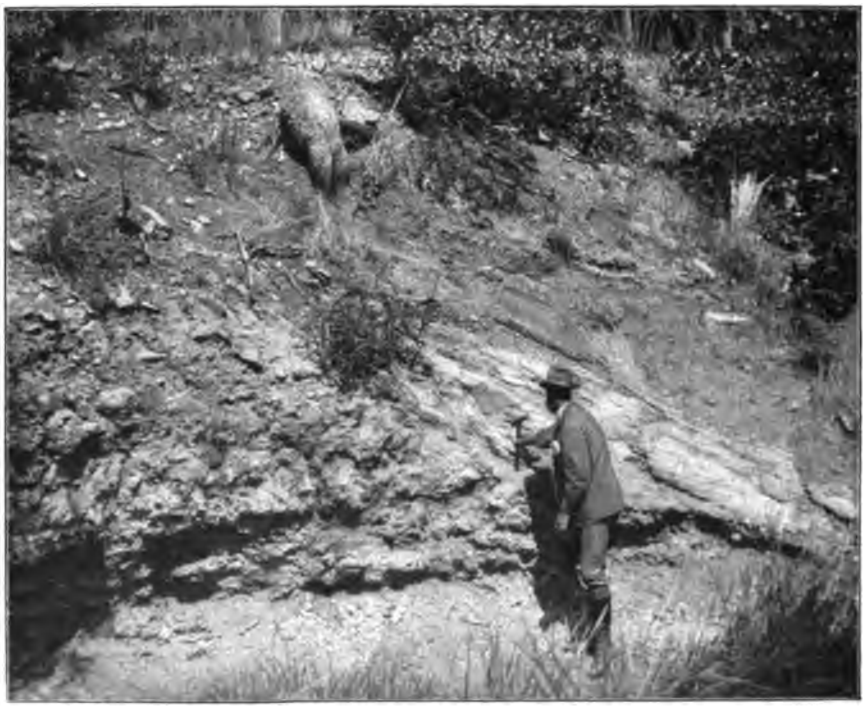
Succeeding the basal conglomerate series are extensive deposits of friable sandstones dipping very slightly toward the west. The outcrop is about 10 miles wide, extending westward from near the western line of the Ardmore quadrangle to the vicinity of Velma. These sandstones contain local deposits of grit and fine conglomerate composed chiefly of foreign quartzitic material consisting of smooth white, red, and blackish pebbles. This sandy formation is so friable that it breaks down readily and forms deep sandy soil, so that fresh exposures of the rocks are of rare occurrence. The main topographic features of this sandstone are low rounded hills and generally wide smooth valleys, which are covered by a sparse growth of scrubby oak timber with thick scrubby underbrush or shin oak. In places the sandstone and grit is indurated and occurs at the surface in large rounded bowlders which weather usually to a brick-red color. The thickness of these sandy deposits can only be estimated, since so few exposures of the rock occur that dips can not be determined. It is probable, however, that it does not exceed 200 feet.

Above the sandy member and continuing from the vicinity of Velma westward to the Wichita Mountains are deposits of bluish, greenish, and red shales, with some grit, thin cross-bedded sandstone, and siliceous limestone. The shales predominate over the other associated deposits to such an extent as to give the topographic appearance and general character of a clay formation. From Velma to Fort Sill the surface is generally smooth and occupied by prairie except in the immediate valleys of the larger streams. Here and there are low buttes and terraces capped by thin sandstone and limestone beds which are interbedded with the shales. So far as observations could be made, these shale beds are practically flat.

Near Fort Sill the sediments undergo certain changes due to their proximity to the Wichita Mountains, which were land masses during a great part if not all of the time in which the "Red Beds" were deposited. In the east side of Cache Creek Valley, southeast of Fort Sill, 60 to 100 feet of the "Red Beds" are exposed in the bluffs, deep gullies, and slopes. Here the deposits consist of red and greenish clays, thin strata of grit and fine conglomerate, and argillaceous limestone. The greenish and red clays in part contain numerous calcareous nodular concretions, which seem to owe their origin, to a certain extent at least, to the segregation of the calcareous matter in the clays during their disintegration. The fresher exposures of the rocks seem to contain fewer of these concretions than appear in the weathered surfaces. Other exposures occur along the eastern side of Cache Creek Valley east and northeast of Fort Sill. On ascending Medicine Creek from its mouth, toward Carlton Mountains, one finds that the conglomerate and sandy beds become more pronounced, many layers being composed of coarse igneous material in a matrix of grit and sand and interstratified with blue clays. Naturally the coarser and more durable beds are best exposed and little can be seen of the clay deposits. At the eastern end of Carlton Mountains, immediately west of the Rifle Range, these conglomerate beds rise at low angles and come in contact with the porphyry. From round and subangular pebbles the material changes westward to angular breccia in the contact with the porphyry. Pl. VIII, *B*, illustrates the contact phenomena in a small gulch entering Medicine Creek at the extreme eastern end of the Carlton Mountains. In the bluff above and upon the east side of the gulch shaly and gritty beds succeed the contact breccia and conglomerate. Wherever the stratified rocks are exposed near the porphyry masses the conglomerate beds are found to be composed chiefly of porphyry materials, though granite bowlders and pebbles are found. Excellent exposures of the conglomerate and grit occur in the deep gullies between the



A. CAMBRIAN SANDSTONE ON GRANITE-PORPHYRY EAST OF BLUE CREEK CANYON.



B. "RED BEDS" CONGLOMERATE ON GRANITE-PORPHYRY AT EAST END OF CARLTON MOUNTAINS.

two easternmost hills of the Carlton Mountains, south of Medicine Creek, and 2 miles west of Fort Sill. Farther up Medicine Creek, south of Mount Cummins, the present stream is found to be located in an old valley which is still partially filled by the "Red Beds" conglomerate. Southeast of Mount Cummins the conglomerate is exposed in numerous places along the bluffs of the creek, and is noted to be composed chiefly of coarse granite conglomerate with occasional bowlders and pebbles of gabbro and diabase dike rocks, the latter of which is found penetrating the gabbro, granite, and porphyry. The mountains upon either side in this vicinity are composed of granite. The gabbro occurs farther up the valley north of Mount Scott.

It has been explained in discussing the geography that the plan and general configuration of the mountains and hills composed of the older rocks originated in Permian time. The contact of the later sediments with these old rocks represents or locates the shore line of the sea at certain stages in Permian time. Since the land masses at that time were not large the conglomerates and associated sediments laid down in contact with them are limited in area and represent materials degraded chiefly by the action of the waves upon the shores. North of Medicine Bluff the porphyry conglomerate gives place to sediments of red clays in the plain, which farther north change to grits and then to coarse limestone conglomerates in contact with Cambrian and Ordovician limestone. Farther northwest, 6 miles north of Mount Cummins, the composition of the contact conglomerate changes from limestone along the strike of the beds to chiefly of porphyry against the porphyry hills. In Blue Creek Canyon 5 miles north of Mount Scott low hills of "Red Beds" conglomerate composed of mixed limestone and porphyry materials are found in the old Permian valley. Similar conditions prevail in all the larger valleys in the limestone hills where the present streams are cutting into and removing the "Red Beds" conglomerates. In the resurrected Permian valley now occupied by a tributary of Cache Creek, which flows across T. 4 N., R. 12 W., the coarse limestone conglomerate is especially well exposed.

All of the streams at the present time flowing from the mountains of the Wichita region are small, and are not degrading the harder rocks with sufficient power to remove coarse materials. Upon entering the "Red Beds" deposits the streams cut into and transport the conglomerate and associated sediments without depositing, as fans or overwash deposits, the fine materials brought down from the igneous and older stratified rocks. The tributaries of Medicine Creek flowing south from the limestone hills in T. 4 N., Rs. 13 and 14 W., cut deeply into the conglomerate and expose the older Ordovician limestones, and make rough low hilly country at the border of the "Red Beds" plain. In the plain between the Wichita Mountains and the limestone hills, and in the wide embayment of the "Red Beds" deposits northwest of Blue Creek Canyon, the relations between the contact conglomerate and red-clay sediments are well shown. In the immediate valleys of the streams flowing south across and from the Quana Mountains the relations between the granite conglomerate and red sediments are the same as between the limestone conglomerates and red sediments above described. In some places especially noted, near Quana Parker's house, in the NE. ¼ sec. 2, T. 2 N., R. 14 W., and in sec. 16, T. 3 N., R. 15 W., the granitic conglomerates occur in a matrix of red, calcareous, gritty clays.

The gabbro of the Wichita region is a hard rock, but it is more easily disintegrated and degraded by erosive agents than either the granite or the porphyry. As a consequence the rocks of the gabbro areas were worn down to lower levels during the transgression of the Permian sea than were the granites and porphyries or even the harder limestones. On account of the nature of the gabbro rocks the contact sediments of the "Red Beds" are composed of finer materials. Coarse gabbro conglomerates have not been found in the "Red Beds." On the contrary, red clays interstratified with calcareous, slightly indurated, gritty beds of red color have been noted to occur in contact with the gabbro. Such sediments were noted especially in the valley of Otter Creek immediately north of the Upper Narrows; also in contact with the small gabbro hill on the banks of Red River in the southeast corner of sec. 6, T. 4 N., R. 18 W. Some of the coarser contact material from the gabbro is slightly angular, and the rock somewhat resembles a tuff.

As the igneous and limestone areas were reduced to small size, isolated and almost submerged during Permian time, no coarse materials were brought into the sea by stream erosion. In consequence the contact sediments of the "Red Beds" in such cases were composed of disintegrated materials in situ. At the present time, therefore, fine sandy sediments of the "Red Beds" are in contact with the small igneous and limestone areas. They are usually surrounded by the level plain, so that recent erosion of streams rarely exposes the sediments in contact with the older rocks.

QUATERNARY ROCKS.

Pleistocene (?) gravels.—In relatively recent geologic times certain gravel and pebble deposits of quartz and quartzites were introduced into the region of the Wichita Mountains and now occupy the high levels of certain divides as well as terraces cut in the igneous rocks associated with some of the larger streams 100 to 200 feet above the general level of the plains. These gravels are well rounded, smooth, and are composed of quartz and quartzitic material of various colors, chiefly of light and dark shades. The gravels were noted especially on the divide east of Fort Sill, near the east line of the present Apache Reservation. They occur simply scattered upon the surface or as a very thin mantle.

Gravels of similar nature were noted also upon the granite mass at the north end of the Lower Narrows, about 6 miles northwest of Snyder. Gravels in this instance occur upon a terrace in the granite representing an old level of Otter Creek before cutting its present narrow and sharp channel. No original materials of the nature of these gravels have been found in the region of the present drainage of Otter Creek, and their occurrence here indicates that they were introduced into the region by a system of drainage and under conditions not now in existence.

STRUCTURE OF THE WICHITA MOUNTAINS.

The Wichita Mountain range, except the group of outlying ridges on the northeastern side and some low detached hills on the southern side, near the eastern end, is composed entirely of igneous rocks. These igneous rocks are separated into more than 250 detached areas, and form mountains and hills which range from closely connected groups of 150 square miles in area to isolated, sharp knobs which rise above the plains like islands. The numerous small igneous mountains and hills in the western half of the range are especially broken and disconnected. All these groups and mountains are surrounded by the nearly horizontal "Red Beds" deposits which extend on all sides of the range for long distances. They conceal the rocks of the Wichita Mountains to such a degree that no adequate conception can be had of the extent of the Wichita uplift. The archipelago-like arrangement of the granite mountains and peaks in the plain leaves one to assume that only a small part of the igneous core of the Wichita uplift is now exposed.

EVIDENCE OF DISTURBANCE IN THE IGNEOUS ROCKS.

These igneous masses of the Wichita Mountains possess certain general, yet pronounced, structural features. The granite has been intruded through the gabbro in part at least, and spread out in a broad way upon it. Where the erosion of Permian and more recent times has uncovered the gabbro in what is now the generally level plain, the gabbro areas are found to be oriented in a direction approximately N. 60° to 70° W., as would be the case if the gabbro had been arched in the axial part of an uplift. The larger areas of granite, especially in the Wichita and Quana mountain groups, and also a great number of the smaller ones, are found to be oriented in the same general northwest-southeast direction.

In the strike of the principal ridges and lines of peaks and hills there are marked zones of fracture or of major jointing. These lines of jointing are especially pronounced in the western part of the Wichita group, south of Mount

AGE OF THE WICHITA MOUNTAIN UPLIFT.

In the discussion of the stratigraphy it was shown that the igneous rocks of the region are pre-Cambrian. The succeeding Cambrian and Ordovician strata, representing approximately 6,000 feet of strata, bear no evidence that they were either folded or uplifted into land at any time during their deposition. The rock section exposed in this region is an almost exact repetition, both in stratigraphy and in structure, of that of the Arbuckle Mountain uplift. As already explained, the Arbuckle uplift began near the middle and culminated near the close of Pennsylvanian time, previous to the deposition of the "Red Beds," which occur now undisturbed between the Arbuckle and Wichita mountains. It has been shown that there is no record to indicate that the rocks of the Wichita Mountain region were disturbed during the deposition of the Cambrian or Ordovician rocks, nor since the formation of the "Red Beds;" therefore the deformation of the rocks occurred between Ordovician and Permian time. The Arbuckle and Wichita mountains occur near together, have the same general form of uplift and structural trends, and show identical stratigraphic sections and igneous cores of similar character and age, which are good reasons for supposing that their uplifting and folding occurred during the latter part of the Carboniferous period. Moreover, since these uplifts are in alignment it is natural to presume that they belong to the same uplift, being separated by deposits which were laid down since the folding occurred.

NOTES ON THE OCCURRENCE OF ORE DEPOSITS IN THE WICHITA MOUNTAINS.

With two exceptions, which include the gabbro, the oldest igneous rock, and a local and very limited dike of grorudite in the gabbro, all the igneous rocks as well as the quartz veins or dikes of the Wichita Mountains are duplicated in the Arbuckle region. The texture of the granites varies in an unimportant degree, but the granite-porphyries, aporhyolites, diabase, and quartz are essentially identical in the two regions. Moreover, they have the same age relations, and all, with the possible exception of some of the quartz, are, without any reasonable doubt, of pre-Cambrian origin.

When the writer made a survey of the Wichita region in 1901, the lands of the Kiowa and Comanche reservations which include it had just been opened to settlers. Practically every dike and igneous rock where it came in contact with another showing contrast in texture or color had been prospected, besides Permian "Red Beds" and Cambrian sandstone and limestone. The light-colored granite or aplite dikes in the gabbro and the points of intersection of such dikes with the diabase dikes, also the quartz bodies and grorudite dike, proved especially attractive to the prospector, and it was easy enough to get favorable reports of the occurrence of gold and silver in samples submitted to some assayers.

As in the Arbuckle region, the contact phenomena between the various classes of igneous rocks, including the dikes, seen by the writer, gave no encouragement to a belief that mineral deposits of value could be found. It is possible, though not considered probable, that the precious metals or their ores may occur in small quantities as original constituents in these igneous rocks.

Following the settlement of the lands of the Wichita region in the spring of 1902, prospecting for the precious metals became more aggressive; the occurrence of rich ores of gold and silver were reported, and at some places mining operations were begun. These activities resulted in civil disturbances between prospectors and homestead owners and made necessary a thorough investigation of the reported ore deposits. The appended report of Doctor Bain is conclusive as to the occurrence of ore deposits of any value in the Wichita Mountains.

REPORTED ORE DEPOSITS OF THE WICHITA MOUNTAINS.

By H. Foster Bain.

INTRODUCTION.

For many years rumors of the occurrence of gold and other ores in the mountains have been rife, and even previous to the opening of the country to settlement considerable prospecting had been done. When the reservation was thrown open to settlement many mining claims were staked out, and repeated announcement of the discovery of ore has stimulated prospecting throughout a wide territory. Local assayers have constantly reported gold and silver values, and occasionally assayers outside the district have found values in ores from these mountains, or reported to be from them. On the basis of these reports a large number of people have located in the territory and attempted its development. There have been numerous conflicts as to title, and much litigation has arisen.

The Wichita Mountains have been visited by a number of geologists, but in all cases their investigations were either hurried reconnaissances or were directed to general problems of geology rather than the study of the reported ores. Under the circumstances it was thought advisable to make a special investigation of the ores, and this was accordingly done by the author in the month of October, 1903.

The important mining camps in the area extending from Lawton to Lugart were visited and samples were taken from the leading mines in each camp. In every instance the effort was made to get samples from the prospects upon which the most work had been done, or where the most encouraging results were reported. It was felt that if even some of these prospects had a demonstrable value, others might reasonably be considered as worthy of further effort, but that if the best prospects had no value, the less encouraging ones were not likely to yield any profit.

MODE OF OCCURRENCE.

The geology of the region has already been discussed in considerable detail by Mr. Taff. It is sufficient for present purposes to recall the fact that the mountains consist of a core of crystalline rocks, including granite,[a] gabbro, granite-porphyry, and certain diabase dikes, the whole partially encircled by a fringe of Paleozoic limestones. The gabbro and the granite-porphyry at least are pre-Cambrian. The granite and the dikes, which include certain rare and petrographically interesting types, are eruptive through the older crystallines.

Prospecting has been confined in general to the area of crystalline rocks. Within that area it was found that rocks in five modes of occurrence were being prospected: (1) Certain well-defined quartz veins which cut both granite and gabbro. (2) Diabase dikes which apparently cut indiscriminately all other igneous rocks. (3) Contact of the granite and gabbro, particularly where, as often happens, the granite sends off into the gabbro long apophyses, or dikes, usually assuming an aplitic phase. (4) Disintegration products of the gabbro. (5) Along simple shear zones in the granite.

It will be at once apparent that, of the classes of occurrences above enumerated, some were of the sort which, in view of the relations of the rocks, might well be expected to warrant prospecting. For example, quartz veins very commonly carry gold and other metals in sufficient amount to make the material an ore, though it is also true that many of the largest and best-defined quartz veins known carry either no values or such low ones as to preclude the working of the vein. Shear zones in granite, on the other hand, very seldom have been found to carry ore, and then only in the immediate neighborhood of well-recognized ore bodies of other types and of considerable richness. Since, however, the miners reported assays to show values in all the sorts of occurrence noted above, samples were taken from both probable and improbable occurrences; and in many cases, as noted below, where no reason was seen for suspecting the presence of any values, the owner or person in charge was invited to select samples of what he considered his richest material. In all cases where the workings were accessible samples were carefully taken across the entire vein. Occasionally these were taken in duplicate, and usually, with hand specimens of the wall rock, specimens of any horses present, etc., so that the occurrence of the ore might, if necessary, be studied in detail. Having in mind the disappointment which has so often come from incomplete or inaccurate sampling, the utmost care was taken to get fair samples of the material which, in case mining was carried on, would be shipped. As already suggested, where any bias was introduced it was in the direction favorable to the miner, and arose from taking picked samples of the better grade rather than average samples of the vein. Whenever possible, with reasonable expenditure of time, the owner or his representative was invited to be present while the samples were being collected. All the usual precautions were taken to prevent possible mixing or salting of samples, and each package was personally opened and identified by the author in the Survey laboratory. In all, over 300 pounds of samples were taken, and 71 assays were made, as detailed below, without in any case showing gold.

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[a] In an earlier reconnaissance trip through the Wichita Mountains, made in 1899, the author studied this granite, and found, as he thought, sufficient evidence for considering it eruptive and post-Ordovician in age. (Bull. Geol. Soc. America, vol. 11, pp. 127-144.) Mr. Taff's fuller studies lead him to believe that the rock is pre-Cambrian. The author believes that the matter is still open to reasonable doubt, but with present knowledge is quite disposed to accept Mr. Taff's determination as probably correct.

LIST OF SAMPLES.

MARY MACLANE MINE.

The Mary Maclane mine is near Meers, a small mining camp on the north of Mount Sheridan. It represents apparently a basic dike cutting through the gabbro. This mine was full of water, and it was impossible to collect any other than the dump sample.

W-1. Sample of vein material collected from dump.

GOLD BLOSSOM MINE.

The Gold Blossom mine is located in the NW. ¼ sec. 11, T. 3 N., R. 13 W. It is known occasionally as the Campbell mine. The workings include a shaft about 65 feet deep, with a tunnel at the bottom driven west a reported distance of 30 feet. As the lower tunnel was full of water it was impossible to collect samples of the vein, except in the short drift about 40 feet below the surface. In the case of each sample the surface was first picked clean and then material was chipped from the whole exposure of the rock. The material thus obtained was quartered down to about 5 pounds weight.

W-2. The sample represents an average across a streak of granitic material cutting the gabbro country rock. It lies next to a north-south dike of some basic rock from which the next sample was taken.

W-3. Sample of basic dike from crosscut noted above.

BUCKHORN MINE.

The Buckhorn mine, in sec. 2, T. 3 N., R. 13 W., shows the usual gabbro country rock cut by a thin sheet or dike of an acid rock, probably related to the granite which forms the main mass of Mount Scott. In the gabbro near the contact with the acid dike are small crystals of pyrites and chalcopyrite. As the mine was full of water it was impossible to collect samples from the face of the workings, and a picked sample was accordingly taken from the best material found on the dump.

W-6. Picked sample of pyrite- and chalcopyrite-bearing rock from the Buckhorn dump.

ROSEDALE MINE.

The Rosedale mine is located in sec. 3, T. 3 N., R. 13 W., and the material being worked represents the clays formed by the distintegration of the gabbro country rock. This material is known locally as a volcanic ash, but has nothing to warrant the designation, as it is simply residual material.

W-8. Average sample from stock pile at Rosedale mine.

THREE BOYS CLAIM.

This claim is in sec. 33, T. 4 N., R. 13 W., immediately east of Meers post-office, on a dike of fine-grained dark greenstone about 3 feet thick, cutting through the ordinary gabbro plain. There are three small shafts along this dike, and assay values have been reported from all of them.

W-10. An average sample of the material of the dike rock, Three Boys claim.

KECK BROTHERS MINE.

This mine is situated near the Three Boys claim, on a cross dike. It shows on the dump shattered greenstone material cemented somewhat by calcite. There is also present a darker, bronze-colored rock which is said to carry values.

W-11. Greenstone recemented by calcite.

W-12. Bronze-colored dike rock.

WILLIE HINTON MINE.

This mine is near the Keck Brothers mine, and is somewhat similar.

W-14. Sample of best appearing ore.

BLACK LODE.

This mine is situated in sec. 34, T. 4 N., R. 13 W. Apparently a big boss of granite in the gabbro country rock.

W-15. An average sample across the face of the granite exposure.

GEORGE WASHINGTON CLAIM.

This claim is located in a saddle on Mount Sheridan. The general country rock is the normal red granite of the region. In the saddle is a dark, coarse-grained gabbro, which is itself said to carry values. It is somewhat cracked and jointed and carries a small amount of quartz in the seams. It is cut by a dike of diabase about 12 inches thick, along the edges of which there has been some contact metamorphism, with the development of a red facies. At one point on this contact is a small vug, which, on careful examination, proved to be entirely calcite. This was pointed out as the rock from which was broken a beautiful specimen of white quartz showing leaf gold. Samples 16, 18, and 19 are from this claim.

W-16. Average sample of coarse-grained rock.

W-18. Sample of contact facies of dike rock.

W-19. Sample of calcite from the vug mentioned above.

MAUD S MINE.

This mine is located in the gabbro plain, immediately south of Meers post-office.

W-20. Micaceous dike rock.

SHAWNEE MINING COMPANY.

The Shawnee Mining Company has a large group of claims located about 1½ to 2 miles south of Meers. These include the Lost Lead, Joe Dandy, Teddy, the Compton, Big Four, and several others. They have been under development for some time, and at the Lost Lead there is a shaft 72 feet deep, well timbered, and fully equipped with all necessary machinery for sinking and general development work. The other mines show prospecting shafts of various slight depths. The claims are located within the gabbro plain, upon various dikes which cut through the gabbro.

W-21. Average sample across the east wall of the Lost Lead at the bottom of the shaft.

W-22. Average sample across the Lost Lead from the west wall at the bottom of the shaft.

W-23. Average sample across the east wall of the Lost Lead about 15 feet above the bottom of the shaft.

W-24. Joe Dandy. Sample of best material, picked from dump by Dr. S. I. Hardin, manager of the property.

W-25. Teddy mine. Sample of best material, picked from dump as above.

W-26. Bismuth mine. Sample of best material, picked from wall of lead by Doctor Hardin. This material has been reported to carry bismuth, but upon examination in the laboratory fails to show any metallic element.

W-27. Big Four mine. Sample of best material, picked from dump by Doctor Hardin.

W-30. John A. Logan mine, of the Madison Creek Mining Company, near the Shawnee mines. Sample from the wall, showing small quantity of molybdenite. Apparently not much material is present, although it is possible that additional work might develop more.

CACHE MINING AND REDUCTION COMPANY, MONTE CRISTO MINE.

This mine is situated in NW. ¼ sec. 18, T. 2 N., R. 13 W. At this point there are three small shafts located in the midst of the red granite country rock. The granite is at this point cut by joints and seams, but not noticeably more so than at many other points in the district. Very small quantities of common pyrite can be found by careful examination. The samples were taken under the direction of the superintendent, and from places which he pointed out as representing the best ore.

W-32. Sample across the south wall at the bottom of the shaft, including about 4 feet in width and showing only the normal granite.

W-33. Sample of soft gouge about 3 inches wide occurring in the southwest corner of the shaft.

W-34. Gouge from the cracked granite, about 5 inches thick, in the northwest corner of the shaft, sampled about 4 feet from the bottom.

W-35. Sample picked from the dump as representing the best ore from the mine.

FLORENCE MINE AT CRATERVILLE.

This mine, which is equipped with a small whim and whose shaft is said to be 100 feet deep, is located upon a greenstone dike cutting across the normal granite country rock. The shaft was partly full of water, and it was impossible to collect samples from the bottom. A sample was taken from the material found in the shaft house and reported by the superintendent to represent ore from the bottom of the shaft. It shows small stringers of quartz with a total thickness of perhaps 2½ inches. This material is reported to have assayed irregularly, but to have occasionally given rather high values.

W-39. Sample of vein material from the Florence, as above noted.

ALBERTA MINING COMPANY.

This mine is situated a short distance northwest of Craterville. The claim is located upon the greenstone dike cutting through the granite, and itself cut by some small veins of quartz having a maximum thickness of three-eighths of an inch.

W-40. Sample across the vein at the bottom of prospecting shaft.

PARKER MINE.

This mine is located not far from the edge of the granite area lying north of Quana Parker's, in the granite country. There is no evidence of a vein. The granite shows small pieces of chalcopyrite sprinkled through the rock, but not in quantity.

W-41. Sample of picked material from dump showing the most chalcopyrite. The assay of this sample gave 0.14 ounce silver to the ton, an amount not commercially important.

LEAD LODE.

This claim is in sec. 22, T. 3 N., R. 14 W. It is located on a granitic dike cutting across the gabbro. The sample was taken from the bottom of an assessment hole, at a depth of 10 feet. This material from the same point is said to have yielded $8 in gold upon assay.

W-42. Sample across the vein as above.

GEM MINE.

This mine is located in sec. 16, T. 3 N., R. 14 W. The working is located upon a greenstone dike, 4½ feet across, sheeted and cemented with white quartz, and itself cutting through the normal granite country rock.

W-43. Sample from across the vein on the west wall at the bottom of the shaft.

DIAMOND MINE.

This mine is about 300 feet east of the Gem, and supposed to be located on the same vein. At this point it shows a noticeable development of quartz on both foot and hanging walls.

W-44. Sample of foot-wall quartz streak, average width 6 inches.

W-45. Sample near hanging wall, shattered greenstone including one streak of quartz.

CLARK AND BENNETT MINE.

This is also known as the Galena mine. It is located a short distance northwest of the Gem and Diamond mines, and shows a greenstone dike about 2½ feet thick cutting through the red granite. This dike has been faulted and considerably broken up. There has been a development of white quartz in the interstices of the broken rock. Accompanying the quartz is galena and some chalcopyrite. The sample taken from here (W-48) was from the dump and represented the best material which could be found. It showed on assay, as noted below, no gold, 0.92 ounce of silver, and 3.63 per cent of lead. The silver value is unimportant. The lead is not enough to give the material rank as an ore. In its present form and in order to make mining pay, it would be necessary to erect concentrating machinery and produce an ore carrying a larger amount of lead. The development work so far accomplished does not show enough lead to warrant this, and while the matter is one of personal opinion, it is not believed that further development work would give any better results.

LITTLE BAR MINE OF THE BIG FOUR COMPANY.

This mine is located a short distance east of Oriana. It has attracted a great deal of attention. It was from it that a carload of ore is said to have been taken and shipped to Denver for sale to Beam & Co. It is reported that this shipment gave a net return of $11.87 per ton. The mine as now developed shows a shaft about 40 feet deep, located on a greenstone dike running through the normal granite country rock. There are no quartz stringers or other signs of mineralization except a very small amount of pyrite along certain fault planes. The dike is 4 to 5 feet wide, varying slightly at different points. It had been suggested that the vein proper pitched to the north and passed out of the shaft at a depth of about 12 feet from the surface, but an examination of the wall at that depth showed no vein or slip planes cutting the north wall, such as would be required by this hypothesis.

W-49. Sample across west wall at the bottom of the shaft.

W-50. Sample picked by the foreman from the east wall about 6 feet from the bottom and said to have assayed $48 in gold.

HOMESTAKE MINE.

The Homestake mine is in the NW. ¼ sec. 18, T. 4 N., R. 16 W. This claim is in the gabbro country, and there are no indications of any vein material.

W-74. Picked sample from dump, said to represent the last bucket of material taken from bottom.

TENDERFOOT MINE.

On same quarter section with the Homestake. The development work consists of an assessment hole 10 feet deep. The material shown in the walls of the hole is a weathered greenstone with some white streaks of feldspathic material. In the southeast corner of the shaft there is a body of hard greenstone from which samples are said to have been taken which yielded as high as 4.40 ounces of gold and 5.44 ounces of silver.

W-75. Sample from the hard greenstone noted above.

OAKS MINE.

This claim is in the NW. ¼ sec. 23, T. 4. N., R. 17 W. It is located on a very fine-grained, glassy, dark rock, forming a dike and cutting through the usual gabbro. There is a development of white quartz along the contact.

W-78. Average sample of dike across the bottom.

W-79. Average sample of white quartz from bottom of shaft.

BONANZA MINE.

The Bonanza mine is in the NE. ¼ sec. 27, T. 4 N., R. 17 W. It is located on white quartz veins cutting the gabbro. Near the surface there are two separate quartz veins, which come together at the bottom.

W-80. Average sample across the bottom on the south side.

TWIN ROSE MINE.

This is on the same land as the Bonanza mine. It is located on white quartz cutting the gabbro. At the surface separate stringers extend through a width of about 10 feet. At the bottom of the prospect shaft, about 20 feet in depth, the thickness is about 2½ fe

W-81. Sample across the vein at the bottom.

FELAND MINE.

This claim is in sec. 11, T. 4 N., R. 17 W. It is located in the gabbro plain, east of the Narrows. The vein shows in the shaft an average thickness of 3 to 3½ feet. It includes several stringers of white quartz cutting through the gabbro.

W-82. Average sample across face, east side, at a depth of 16 feet.

CREYCRAFT MINE.

This claim is three-quarters of a mile northeast of Wildman. It is located on a greenstone dike cutting through the gabbro.

W-83. Sample of material picked by owner.

JOSHUA LODE.

This lode is in the SW. ¼ sec. 15, T. 4 N., R. 17 W. It consists of thin quartz streaks cutting through the gabbro, with a total thickness of 4 inches at the bottom, spreading apart to 6 inches at the top. The sample was taken from both sides of the assessment hole and from top to bottom.

W-84. Sample quartz vein as above.

ARKANSA MINE.

This claim is in the SW. ¼ sec. 17, T. 4 N., R. 17 W., on a well-defined greenstone dike, 4 feet wide, cutting through the gabbro.

W-85. Average sample across dike at bottom of assessment hole.

GLEN RAVEN MINE.

This claim is in sec. 12, T. 4 N., R. 18 W. It is located within the gabbro area and upon the greenstone dike cutting through the gabbro. Near both foot and hanging walls there is a development of pink feldspathic rock.

W-86. Average sample across dike.

SNOW BIRD MINE.

This mine is on the same land as the Glen Raven. It is located on a quartz lead cutting through the gabbro. The sample was taken from the bottom of a 10-foot hole and across a width of 3½ feet, showing quartz and pinkish decayed feldspar developed along the contact of a fine-grained intrusive rock cutting the gabbro.

W-87. Average sample across face.

LUGART MINING COMPANY.

The Lugart Mining Company is engaged in the development of a number of properties lying near Lugart post-office and known as the Devils Canyon District. These include the Grubstake claim, from which ordinary blue bottom-land clay is being taken and treated by a new secret leaching process which is supposed to yield "from 20 to 30 per cent more than is shown by fire assay." The average yield of treatment so far is represented to be about $60 to the ton. Samples were taken from the face of the cut in the presence of the assayer and inventor of the process, C. F. Lawrence, and were considered by him to represent a fair average of the material treated. On the same claim a shear zone in the granite is being worked. On the Black Diamond claim, near by, is a big dike of greenstone about 8 feet across and running through the granite in a north-south direction. Higher up the hill is a development of pegmatite and a small cave showing quartz crystals.

W-90. Average sample taken from the face of pit and showing blue clay with occasional small balls of pyrites.

W-91. Duplicate sample taken from same pit.

W-92. Sample of sheared granite from assessment hole on Grubstake claim.

W-93. Average sample across the south wall of assessment hole made on the greenstone dike.

W-94. Sample picked by W. J. Gilbreath, superintendent of the company, and representing the best material from the Black Diamond claim. This material is reported to have yielded, in assays made by Lawrence, $3,300 to the ton.

W-95. Sample from the pegmatite dike, picked by Mr. Gilbreath and including crystals of quartz.

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